THE TECH ENGINEERING NEWS

MEMBER OF THE ENGINEERING COLLEGE MAGAZINES ASSOCIATED

VOL. VII, No. 7 JANUARY, 1927

LIBRARY FEB 10 1927

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASSACHUSETTS

Lead has a lot to say about your *gasoline*

PROBABLY you never realized what a necessary business the petroleum industry is until, one dark night, the old bus wheezed to a stop and you had to walk the traditional weary miles to the nearest gas station.

Right there, as the pump gurgled out the precious liquid, you should have raised your hat in silent tribute to—Lead. But you didn't know what a good bit of service lead was doing you.

Lead has found itself several essential jobs in the petroleum industry.

In the first place, oil wells often give out more water than oil. The most economical way to shut off the flow of water is to drop a plug of EAGLE Lead Wool into the bottom of the well. Pressure pounds the lead wool into every water crevice and stops the flow at once.

Then, too, lead is the basis of EAGLE Rope Socket Metal, scientifically developed alloy used for socketing wire rope, much used in the oil fields.

Once out of the wells, petroleum has to be refined before you can get the oil or the gasoline you need. During the refining process lead has some more work to do. Sulphuric acid is used to treat the oils, and lead lines the tanks, the pipes and valves through which the fiery acid passes. After the acid has done its work, lead, in the form of lead monoxide, extracts the sulphur compounds, and leaves the refined oils free from impurities.

In practically every modern industry lead is at work, just as in the petroleum industry. Productive research in the Eagle-Picher institution is constantly on the watch for new uses for lead. Tomorrow, when industry's developing processes require new services from lead, Eagle-Picher will be ready to supply the need.

The uses of lead in modern industry, in modern life, are many and interesting. Send for your free copy of the Lead Tree.

The EAGLE-PICHER LEAD COMPANY · 134 *North La Salle Street* · *Chicago*

EAGLE-PICHER

[Producers of Lead and Allied Products]

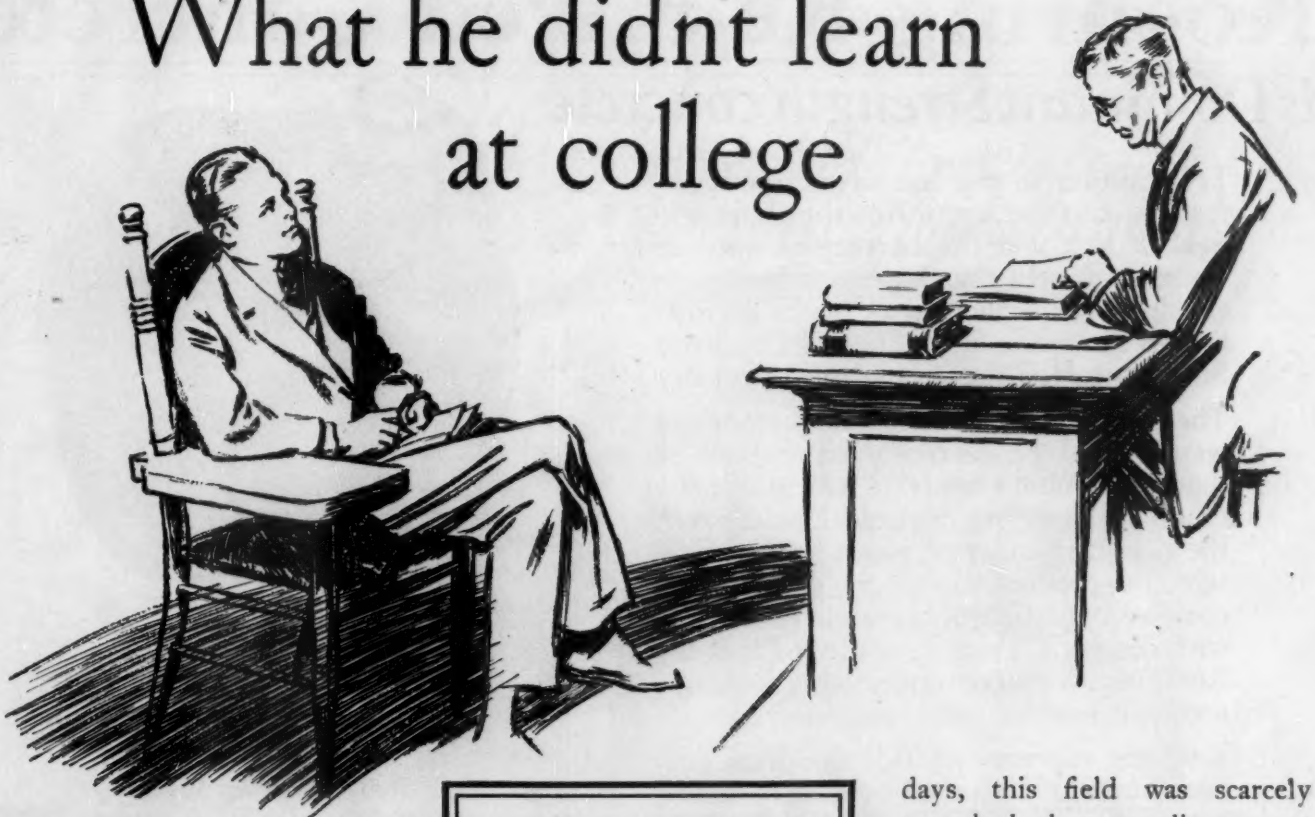
Sales Offices

CINCINNATI CLEVELAND PITTSBURGH PHILADELPHIA NEW YORK MINNEAPOLIS
BOSTON BUFFALO DETROIT BALTIMORE NEW ORLEANS KANSAS CITY ST. LOUIS JOPLIN

Manufacturing Plants

CINCINNATI NEWARK, N. J. GALENA, KAS. HENRYETTA, OKLA. PICHER, OKLA. CHICAGO
EAST ST. LOUIS, ILL. ARGO, ILL. JOPLIN, MO. HILLSBORO, ILL. ONTARIO, OKLA.

What he didn't learn at college



LAWRENCE DAY HOWELL

In his class work, Lawrence Day Howell, Princeton, Litt. B. '13, E. E. '19, never heard of marine applications for electrical equipment. In fact, they were practically unknown. Yet he now is in charge of the Marine Section, Transportation Division, of the Westinghouse Sales Department, located at New York.

When Howell came from college to the Westinghouse Graduate Students' Course, he had twelve months of thoroughgoing work in the shops at East Pittsburgh. Then he decided he wanted to enter the field which seemed most undeveloped and perhaps most promising of broad expansion. This was marine engineering.

"What's the future with a large organization?" That is what college men want to know, first of all. The question is best answered by the accomplishments of others with similar training and like opportunities. This is one of a series of advertisements portraying the progress at Westinghouse of college graduates, off the campus some five—eight—ten years.

Not five per cent of the present opportunities on the water have been opened for electrification. Yet there is more horsepower, in prime movers, on the ocean than there is on the land.

In Howell's undergraduate days, this field was scarcely scratched—just as radio was not known to many young engineers when they were in college. A college man's opportunities are not limited to the electrical developments now in existence.

In marine applications an order may assume large proportions. A single installation, negotiated by Howell recently, of the newly-developed Diesel-electric drive for a yacht, totaled $175,000. Such sales are not made overnight. They result from understanding fully a customer's needs.

To men with the knack of taking the other fellow's point of view, a career as Sales Engineer at Westinghouse brings returns in personal satisfaction as well as in worldly reward.

Westinghouse

Koehring Re-mixed Concrete

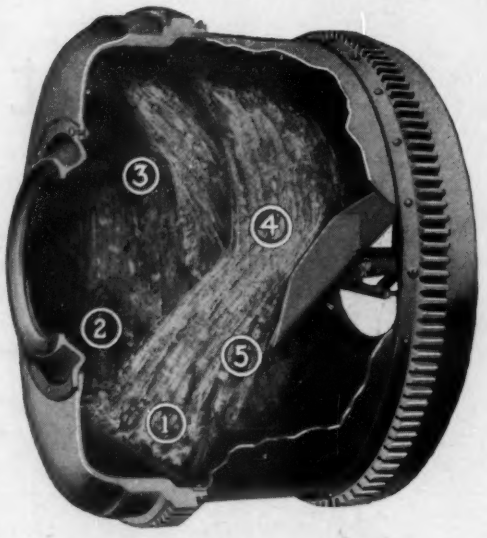
is Dominant Strength concrete

IN addition to the use of proper aggregates, positive control of the thoroughness of mix and the correct amount of water accurately timed, there is finally, an essentially important factor in the production of standardized concrete of Dominant Strength. It is the proper mixing action.

The raw materials—cement, sand, stone and water—must be so combined and mixed that the resultant concrete will be of maximum strength and quality. The drum of the Koehring concrete mixer has been designed to produce a re-mixing action which coats every particle of aggregate thoroughly with cement. Tests have proved that the Koehring five action re-mixing principle accomplishes this most completely.

Koehring supremacy inside the drum goes even further. With the Koehring re-mixing action there is no separation of aggregate according to size—it is uniform to the last shovelful of every batch.

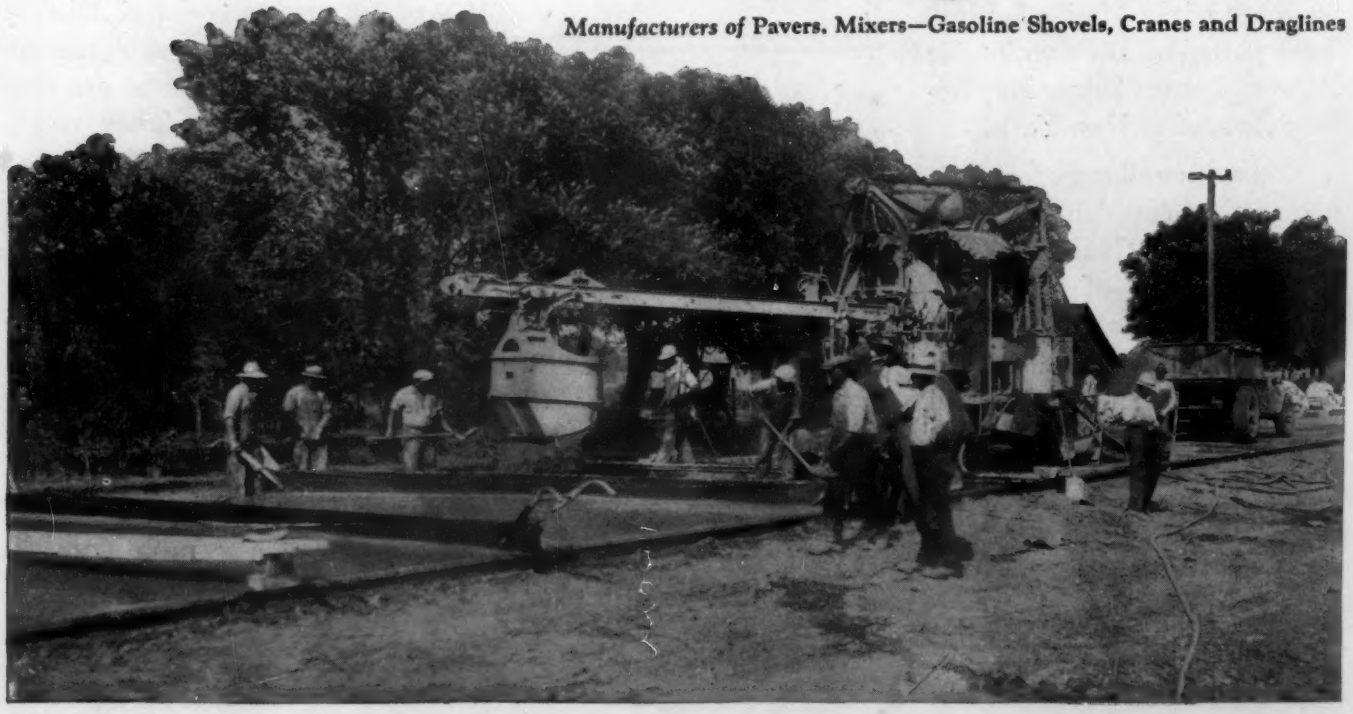
"Concrete—Its Manufacture and Use" is a 210 page treatise on the uses of concrete, including 26 pages of tables of quantities of materials required in concrete paving work. To engineering students, faculty members and others interested we shall gladly send a copy on request.



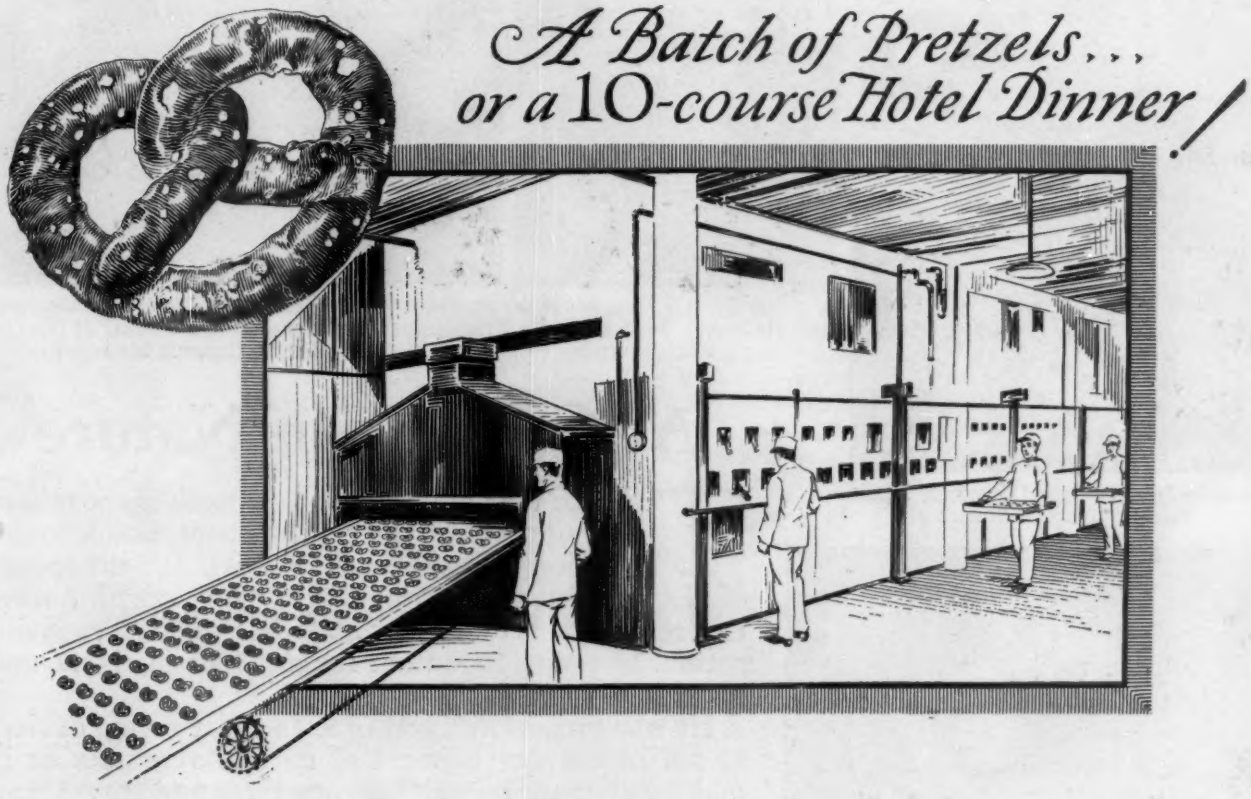
(1) Blade cuts through materials with churning action. (2) Blade carries materials up, spilling down again against motion of drum. (3) Materials hurled across diameter of drum. (4) Materials elevated to drum top and cascaded down to reversed discharge chute which (5) with scattering, spraying action, showers materials back to charging side for repeated trips through mixing process.

KOEHRING COMPANY
MILWAUKEE WISCONSIN

Manufacturers of Pavers, Mixers—Gasoline Shovels, Cranes and Draglines



There's Romance *in the* Story of Gas as a Practical Fuel



Boston Delicatessen Shops *and* Hotels DEPEND on Gas Fuel

GAS Fuel is indispensable in the mass production of food products. Bakeries use it for their daily output of bread and cake. Packers use it for preparing meats and canning fish, fruit and vegetables. Restaurants and hotels use it to prepare luncheons and all kinds of food. They find gas unfailing. It is automatically controlled to provide the exact temperature required. It cuts fuel cost by its quick results. Bakers and chefs like the cooler temperature in which Gas Fuel allows them to work.

Over 1600 industrial users in Boston, including many bakeries, restaurants and hotels, are satisfied that the Boston Consolidated Gas Company produces their best heat supply.

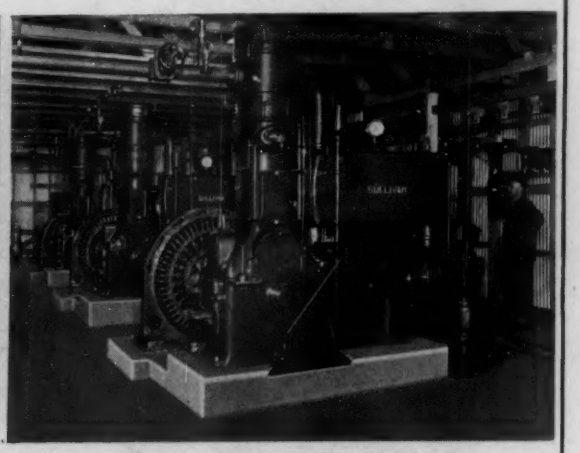
"Fuel by Pipe Line"
Some of the many industrial uses of Gas Fuel provide heat for annealing copper wire, hardening steel, pasteurizing milk, pressing and steaming hats, baking, cooking, hardening lead, tempering oil, forming hosiery, etc.

ASK THE INDUSTRIAL DEPARTMENT OF BOSTON'S GAS COMPANY HOW GAS FUEL IS PROVING ITSELF PRACTICAL FOR YOUR BUSINESS

GAS Boston Consolidated Gas Company FUEL

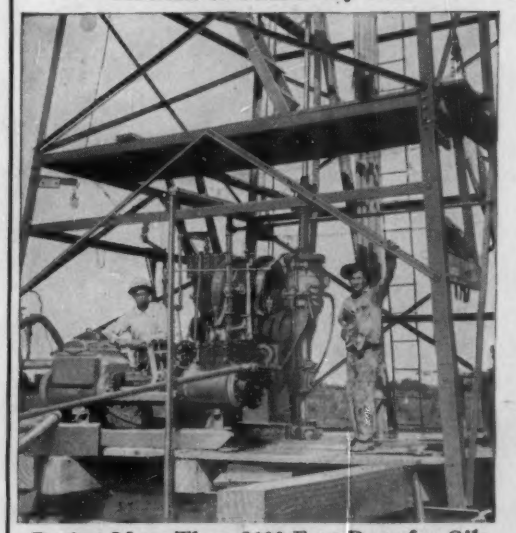
Hundreds of Sullivan "Stoping" Drills Win Copper Ore at Butte

A Portable Air Compressor and Hammer Drill Excavating a Rock Trench



Sullivan "Angle-Compound" Air Compressors Helping to Build the 8-mile Tunnel of the Great Northern in the Cascade Mountains

"Ironclad" Electric Coal Cutters Mine Millions of Tons Every Year



Boring More Than 2100 Feet Deep for Oil, with a Sullivan Diamond Core Drill

At Grips with Nature

THERE is an appeal about the work of the miner, the quarry man, the civil engineer, which comes from its reality—its genuineness. It's the appeal of the frontier, the appeal of the struggle with nature to wrest from her the raw materials of modern civilization, to pierce mountain ranges, control rivers, and carve highways.

He who brings labor and time and cost saving devices to aid in the development of natural resources or in making the way smooth for commerce and travel, renders a service as genuine and as valuable as that of the actual driver of the tunnel or builder of the dam.

Wherever minerals are sought, the Diamond Core Drill, a Sullivan product, is known and relied upon. Sullivan Air Compressors and Sullivan Rock Drills, Coal Cutters and Hoists, with nearly 60 years of manufacturing experience behind them, are standards of labor saving efficiency the world over.

The Sullivan Machinery Company, incorporated in 1869, is managed and staffed by engineering graduates. Sullivan engineers are leaders in the service of industry.

Catalogues concerning Sullivan products will be sent at your request.

A booklet "Engineering Opportunities with the Sullivan Machinery Company" is yours if you want it

SALES OFFICES IN THE UNITED STATES

Birmingham, Ala.; Boston, Mass.; Butte, Mont.; Claremont, N. H.; Cleveland, Ohio; Dallas, Texas; Denver, Colo.; Duluth, Minn.; El Paso, Texas; Huntington, W. Va.; Joplin, Mo.; Knoxville, Tenn.; Los Angeles, Calif.; Muskogee, Okla.; New York; Pittsburgh, Pa.; Pottsville, Pa.; Salt Lake City, Utah; San Francisco, Calif.; Scranton, Pa.; Spokane, Wash.; St. Louis, Mo.; Terre Haute, Ind.

FOREIGN SALES OFFICES

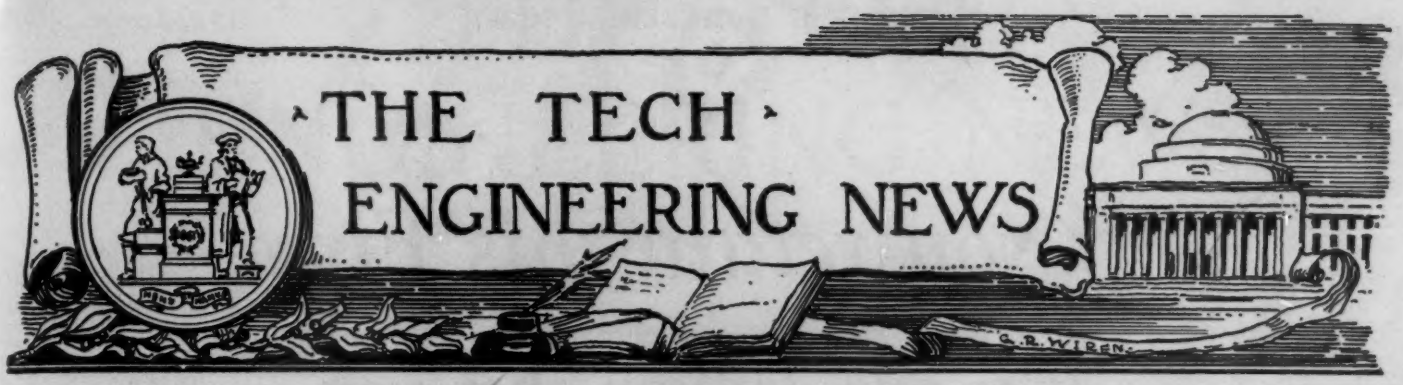
Algiers, Africa; Antofagasta, Chile; Brussels, Belgium; Calcutta, India; Durban, Natal; Honolulu, Hawaii; Johannesburg, Transvaal; Katowice, Poland; Lima, Peru; London, England; Madrid, Spain; Manila, P. I.; Mexico City; Oslo, Norway; Paris, France; San Juan, Porto Rico; Santiago, Chile; Shanghai, China; Sydney, Australia; Tokyo, Japan; Toronto, Canada; Turin, Italy; Vancouver, B. C.; Wellington, New Zealand.

COMPRESSORS · AIR LIFT · COAL CUTTERS · DIAMOND CORE DRILLS · ROCK DRILLS
PORTABLE HOISTS · DRILL SHARPENERS AND FURNACES BUSTERS · SPADERS

SULLIVAN TRADE MARK MACHINERY COMPANY

NEW YORK LONDON PARIS TOKYO SYDNEY

164 South Michigan Avenue, Chicago, Illinois



Volume VII CAMBRIDGE, MASS., JANUARY, 1927 Number 7

Copyright 1927 by The Tech Engineering News

Entered as second class matter, June 1, 1920, at the Post Office at Boston, Mass., under the Act of March 3, 1879.
Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized November 3, 1920.
Published monthly throughout the school year by the undergraduates of the Massachusetts Institute of Technology for the purpose of disseminating news of scientific and industrial interest and of promoting closer co-operation between Alumni and undergradutes.

THE MANAGING BOARD

GEORGE B. DARLING, JR., '27 — *Editor*
EDWARD D. TRUE, '27 — *General Manager*
JAMES P. F. PILKINGTON, '27 — *Business Manager*
JOHN A. CARVALHO, '28 — *Advertising Manager*
WINTHROP H. TOWNER, '28 — *Associate Editor*
MARSHALL W. JENNISON, '27 — *Managing Editor*
JOHN S. MIDDLETON, '28 — *Circulation Manager*
ROBERT A. NADLER, '27 — *Publicity Manager*

EDITORIAL DEPARTMENT

THE EDITORIAL BOARD

F. T. KURT, '27, Assistant Editor
J. J. MAZZONI, '29, News Editor
T. H. SPELLER, '29, Assistant Managing Editor
A. K. STRICKER, Jr., '29, Features Editor

STAFF

N. H. BALL, '29
J. L. HERZOG, '28
G. J. MEYERS, JR., '29
H. MOSER, '27

BUSINESS DEPARTMENT

THE BUSINESS BOARD

R. E. CRAWFORD, '28, Assistant Circulation Manager
W. BAUMRUCKER, JR., '29, Assistant Advertising Manager
W. H. PHILLIPS, '28, Assistant Advertising Manager

STAFF

E. P. WEATHERLY, JR., '29
A. TAMMARO, '28
D. H. WILSON, '29
C. F. HOLDREDGE, '29
J. E. HOWARTH, JR., '29
R. W. STOBER, '27
C. J. CUSTER, '29

THE ENGINEERING COLLEGE MAGAZINES ASSOCIATED

Chairman, Prof. Leslie F. Van Hagan, Madison, Wisconsin

The Transit
Iowa Engineer
Colorado Engineer
Nebraska Blue Print
Pennsylvania Triangle
Sibley Journal of Engineering
Purdue Engineering Review
Rose Technic
Michigan Technic
Ohio State Engineer
Minnesota Techno-Log
The Tech Engineering News
University of Virginia Journal of Engineering
Wisconsin Engineer
Penn State Engineer
Technograph
Cornell Civil Engineer
Kansas State Engineer
Kansas Engineer
Princeton E. A. News Letter
Armour Engineer

Subscription, per year, $1.50
Address all communications to The Tech Engineering News, Walker Memorial, Cambridge 39, Massachusetts. Telephone, University 6864
Advertising rates upon application

TABLE OF CONTENTS

Page

THE TECHNICAL GRADUATE AND TRANSPORTATION. By Edward S. Jordan . 311
MODERN FIREWORKS. By A. F. Clark 312
AEROGRAPHY. By Alexander McAdie 314
A STUDY OF THIN BRICK PAVEMENTS. By L. W. Teller and J. T. Pauls . . . 316
WELDING ALL-STEEL AUTOMOBILE BODIES. By J. W. Meadowcroft 319
PURDUE'S PERSONNEL SYSTEM. By J. E. Walters 321
EDITORIALS 325

*"If you retain this Firm**—

It is our opinion that you will get the best engineering service that is available in this country, that the work will be done within the estimate they furnish you, and that they will produce a structure which will be definitely permanent and durable."

*Part of a letter from a Stone & Webster client to a prospective client

STONE & WEBSTER
INCORPORATED

DESIGN · BUILD
OPERATE
FINANCE

BOSTON, 147 MILK STREET
NEW YORK, 120 BROADWAY
CHICAGO, FIRST NATIONAL BANK BLDG.
PHILADELPHIA, REAL ESTATE TRUST BLDG.
SAN FRANCISCO, HOLBROOK BLDG.
PITTSBURGH, UNION TRUST BLDG.

JAN27'27
©C: B 732971

THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME VII JANUARY, 1927 NUMBER 7

The Technical Graduate and Transportation

Interesting generalizations from the pen of the famous motor-car executive written in his characteristic style

By EDWARD S. JORDAN
President, Jordan Motor-car Co.

IF I were a student at Tech and there was a question in my mind as to what field I should enter after leaving college, I should choose some department of the business of transportation—the greatest business in the world.

Three things have determined the economic and cultural progress of the world—transportation, agriculture and communication.

That nation which attains the highest economic development in these crafts will always dominate the world.

They constitute the measure of civilization because the spread of civilization depends upon the reduction in the cost per ton mile of transportation—the reduction in the cost of food production and the broad dissemination of education through rapid communication.

When the first farmer produced a little more on his little plot of ground than he could use himself he carried it on his back to the nearest market, sold it to his less thrifty neighbor and brought back a profit to invest in larger production.

When he carried his first load on his back to the market his cost per ton mile was very high, but he was widening the radius of his market.

Then he invented the wheel to further reduce the cost per ton mile and as he broadened his market, increased his contacts with people and started trade, civilization really began, and since all cultural progress must have an economic background, this also was the beginning of culture.

When the Phoenicians developed the sailing vessel to reach the markets on the shores of the Mediterranean they made the next great contribution in the effort to reduce the cost per ton mile.

Then followed the efforts of the Spanish, the Portuguese, the Dutch and the English.

When the British Frigate defeated the Spanish Armada the English became ruler of the seas, not because they had the most powerful navy but because they had the means of reducing the cost per ton mile of sea transportation.

Follow through the development of transportation coincident with the great railroad development, the building of canals, the invention of the automobile and the aeroplane by Americans. Each successive step in the building of good roads and the widening of the market has meant a lowering of the cost per ton mile.

That is why our nation today possesses three hundred billion dollars of the world's wealth against ninety billions, that of our nearest rival, Great Britain.

If you will read the history of the nations of the world you will discover that the leading nations are those in which the cost per ton mile has reached the lowest point.

It means a wider distribution of merchandise, a wider market in selling, a higher standard of living, higher wages and therefore higher cultural development.

The automobile business from the standpoint of world wide distribution, is just beginning. While there are nearly twenty million automobiles in this country there are only about five million in all the world beside. Five hundred thousand of these were shipped last year. This is the most important fact in the economic world today, not because it means merely an increase in the export business for the automobile companies, but it means something vastly more important.

I have always maintained that the solution for the European problem would lie in the introduction of two million Fords and two million telephones.

Transportation and communication break down the barriers of religion, language, prejudice and competition and promote understanding with resultant cooperation, and that should be the aim of the world.

The bus and truck departments of the industry are just in the infantile stage.

The saturation point will never be reached in the business of individual and group transportation until every civilized community on the face of the earth and every single individual who can afford transportation has some means of transportation, and none ever wears out.

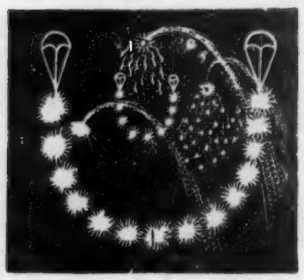
Transportation will be definitely allied with the development of hydro-electric power. Not only will there be wide electrification of the transportation facilities, but hydro-electric power will be used in many interesting ways.

Ford knows that Mr. Atterbury of the Pennsylvania Railroad was right when he said: "There can be produced with the cheap water power at Muscle Shoals a kind of metal that will revolutionize the transportation of the world. This will be an alum-

(Continued on page 332)

Modern Fireworks

A consideration of a few phases of the pyrotechnist's art as applied to the more popular products of this unique industry



By A. F. Clark
General Superintendent, National Fireworks Corporation

FIREWORKS as made in the United States today, comprise in all several hundred different devices each with various colors or combination of colors. Included in one list are such things as firecrackers, pin wheels, rockets, bombshells, fountains, waterfalls, as well as the more elaborate set pieces—pyrotechnical photographs, patriotic sets, American flags, eagles, shields, etc. It would be impractical to attempt to deal in this article with fireworks as a whole but the writer will try to describe two or three phases of the industry including the most striking examples of the effects of blending chemicals, metals and various salts together with carbons, etc., to produce color effects as well as a few of the more important details of the mechanical construction.

The basis of all fireworks is of necessity gun powder or what is commonly known as black powder, it being the most practical as well as perhaps the safest driving force known in the fireworks industry.

PINWHEELS

A pinwheel is propelled by means of rapidly escaping gases from burning gunpowder. The powder is packed firmly into a paper tube having a small outlet at one end through which when properly ignited the hot gases escape. These rushing gases pressing against the atmosphere push the tube in the opposite direction, causing the tube which is attached to a disk of paper or wood to revolve about a pin placed in the center of the disk. In order to balance the wheel, a tube of equal weight is attached to the opposite side of the disk and the two are so matched that only one burns at a time. After burning through the first tube the fire is communicated to the opposing tube by means of a quick match. In order to time the gun powder to drive the wheel at the proper speed, it is made slower than ordinary black powder. This is done by adding a surplus of charcoal; by so doing any speed may be obtained. While the wheel revolves rapidly, sparks of the burning charcoal are thrown out in profusion.

ROCKETS

The same driving force is used in propelling a rocket, the only difference is in the proportion of saltpetre, sulphur and charcoal used in conjunction with the different mechanical forms of charging spindles. In making a rocket the usual method is to roll a strong paper tube about ten inches long on a round spindle of about an inch and a quarter in diameter. The wall of this tube is ordinarily a quarter of an inch thick or over, and the best grade of Bird's hardware paper is used. The spindle inside the tube is about seven inches long. A hollow rammer is used to load the rocket. The first thing that is inserted into the tube about the spindle is fireclay. This is packed down by hydraulic pressure or if loaded by hand, may be packed by blows from a mallet. If packed by press, the pressure necessary to imbed this ring of clay firmly into place so that it will withstand the pressure of the escaping gases is about five tons per square inch.

The composition which is made of the usual black powder mixture, saltpetre, sulphur and charcoal, is varied to suit the speed required of the rocket, and is pressed in in the same way as the clay, a small portion being put in in each charge so that the mass may be hard enough to be self-sustaining after the spindle has been withdrawn. The composition is, in this way, loaded up to the top of the spindle. Beyond that point, a solid rammer is used in place of the hollow one. The composition beyond the top of the spindle is usually of a slower burning type and is pressed in damp. On top of this a charge of clay is pressed home by means of a tool called a "heading rammer" with a hollow tube projecting on the end so that a clay ring is formed with a hole through the center of it to allow the hot gases to escape through the top. See diagram.

After the rocket has attained its height, these hot gases ignite a bursting charge of gun powder placed in the chamber in the head of the rocket beyond the top clay ring. This chamber we will call the blowing chamber. The powder is confined there by means of a sheet of Kraft paper pasted over the end of the rocket tube. Now when the rocket is ignited at the open or choke end, the fire instantly extends to the entire burning surface of the inside of the driving case of the rocket. This burning surface is the exposed surface of the composition represented by the outside area of the spindle, after the same has been removed. The large burning surface causes a very large volume of hot gases to be delivered through the clay choke, which causes the rocket to make a quick get-away.

To guide the rocket straight in its flight, a stick is attached. For the size described above, a piece of soft light wood, about 3/8″ x 3/8″ x 5′ is wired on so that about 52 to 54 inches of the stick project beyond the choked or open end of the rocket. In preparing to fire this rocket, a V-shaped trough is stood up at an angle of ten or fifteen degrees from the perpendicular. It must be braced firmly. The rocket is laid into the trough stick end down, and in this position a piece of slow match inserted into the open end or choke will ignite the propelling charge and instantly the rocket speeds on its way. The driving charge, if properly mixed and placed, the rocket will travel rapidly, gaining speed as the burning surface of the interior is increased and until the wall of composition has been consumed, the thinner wall near the choke will, of course, be consumed first. The greatest speed of the rocket will be attained at about 350 to 400′ from the ground and up to 600′ or 1000′ the rocket will slow up and at or about its highest point, the rocket being heavier at the top end

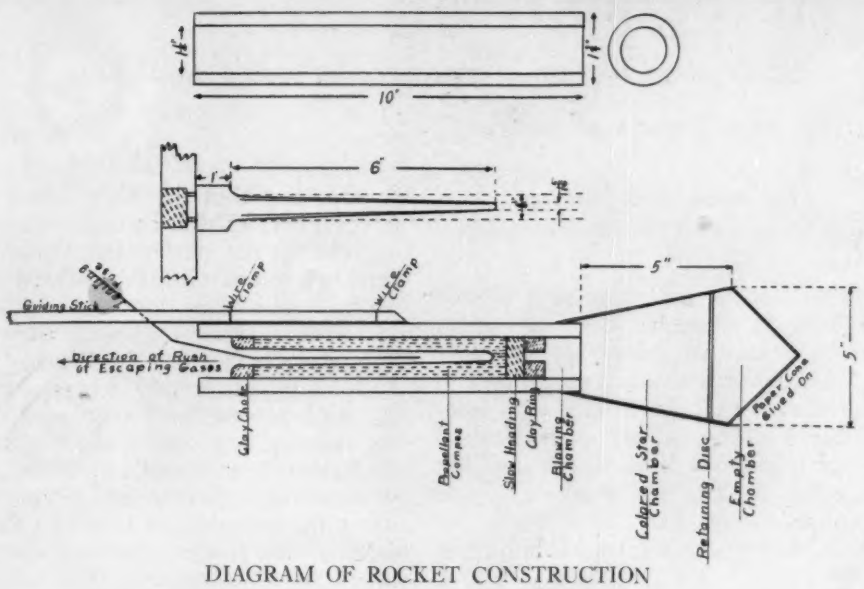


DIAGRAM OF ROCKET CONSTRUCTION

will naturally start to turn over. At this point in the trajectory the gases burn through the upper clay ring and flash thru into the blowing chamber, setting off the blowing powder. This flash extends into another chamber known as the head which is a thin paper tube attached to the top end of the rocket furnished with a cone shaped cap.

In this head is a quantity of stars which the blowing charge ignites and blows out into space. These burning stars are what one sees when a rocket bursts or opens in mid air. If the ordinary commercial black powder were used in the driving or propelling charge, the rocket would be blown to pieces in the trough, but by making a slow mixture with a surplus of charcoal two things are possible. First, the mixture is kept slow enough so that the paper tube will stand the strain of the rapidly expanding gases and second, the surplus of charcoal is deposited partially burned into the air leaving the comet like trail as the rocket ascends.

Up to now we have dealt with the driving or propelling charges of slow gun powder. Now we will deal with the vari-colored stars projected from the head of the rocket at its highest point. These stars are made from various chemicals, metals, salts and carbons.

Red: Formula A

Potassium chlorate $KClO_3$	16 parts
Strontium carbonate	4
Orange shellac	2

The mixture is moistened slightly with alcohol, rolled out like dough and cut into small squares, and then allowed to dry hard. These placed in a rocket head show up well and if cut into 1/2 inch cubes will burn 3 to 4 seconds during descent.

A beautiful green may be made by using:

Green: Formula B

Barium chlorate	6 parts
Strontium nitrate	16
Potassium chlorate	2
Orange shellac	3

The mixture is moistened, rolled and cut as in Formula A.

For silvery white use

White: Formula C

Barium nitrate	20 parts
Potassium nitrate	12
Metal magnesium	8
Orange shellac	4

The mixture is moistened, rolled and cut as in Formula A.

Gold: Formula D

Potassium chlorate	4 parts
Strontium nitrate	12
Sodium oxalate	2
Finely ground wood charcoal	1/4
Orange shellac	4

The mixture is moistened, rolled and cut as in Formula A.

Examples of these colors are found in the following formulae:—

Purple: Formula E

Potassium chlorate	10 parts
Calomel	4
Paris Green	1
Shellac	1
Copper carbonate	1

To moisten use one-half alcohol mixed with one-half water, called 1/2 + 1/2.

Amber: Formula F

Potassium chlorate	10 parts
Strontium nitrate	16
Red gum	2
Sodium oxalate	2
Wheat flour	1

To moisten use one half alcohol and one half water.

Blue Aluminum effects: Formula G

Potassium chlorate	7 parts
Red gum	1
Calomel	1
Powdered aluminum	3
Magnesium carbonate	1/4

To moisten use one-half alcohol and one-half water.

Silvery Green: Formula H

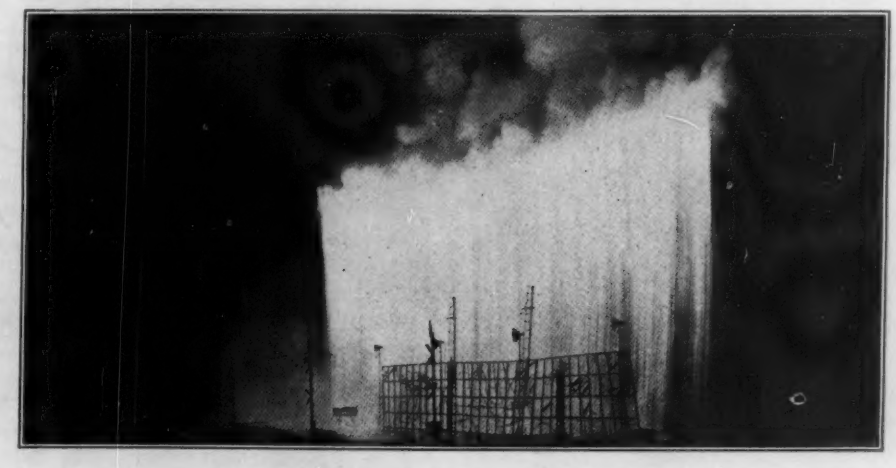
Barium chlorate	6 parts
Barium nitrate	4
Powdered alum	2 & 1/2 to 3
Shellac	1

To form into pellets moisten slightly with alcohol.

There are, of course, many other formulae that may be and are often used, and these colors may or may not be used in the stars.

Any of these colors may be made and pressed out into pellets in a moist state, but not in a pill machine, as most of the best color mixtures will not stand a hard blow when dry. Care must also be taken in mixing. Water must never be used alone in moistening composition that contains both aluminum in the powdered form and barium chlorate as the mass heats up quickly. Therefore with barium chlorate and aluminum powders one-half water and one-half alcohol or pure alcohol must be used. Students of pyrotechnical chemistry must exer-

(Continued on page 340)



"NIAGARA FALLS" IN FIREWORKS

Aerography

A brief but interesting article dealing in a straightforward manner with this unusual subject

By ALEXANDER MCADIE
Director Blue Hill Observatory

THE word may seem somewhat unusual at first glance but it is now established and in current use. It was coined by the writer ten years ago and used as he supposed for the first time in his book "Principles of Aerography." Certain purists in a well known city, took exception to the author's right to coin and introduce such a word. They called it a hybrid and other opprobrious names; but after some search it was found in a certain authoritative dictionary and defined in terms almost identical with our own—namely—the science of the air. The laugh was on my critics equally with myself.

We have geography—the study of the earth; hydrography for the water. Why not then have aerography—the science of the air?

I would like to be bold enough to spell the word *airgraphy*; and this may come in time, for it is not so long ago that we spelled airplane, aëroplane; and we speak of airmen and airships, not aërovires and aëronaves.

The reason for scrapping the old term meteorology, is that for one thing it too closely resembles metrology—the science of measurements. Again it has too many syllables and generally is mispronounced. More significant than these however, is the fact that there is a separate and important branch of astronomy dealing with meteors and meteorites, and the word should be restricted to this, its legitimate sphere.

In lieu of meteorologist which is the current designation of Weather Observer, we might very well coin the word Airscopist—one who watches the air.

Now men have watched the air and observed the clouds for many years; but it is only within our own day and generation that men have watched the air as a medium of transportation and rapid communication. Men had watched the waves of the sea for countless ages; but it was only when ships driven by steam came into existence that modern marine engineering with all its branches began. So with the air and airships. Air liners probably will displace to large extent, the present greyhounds of the sea. Unlike the transoceanic carriers they will not be stopped by shores but will operate on world wide circuits. The student at Technology to-day may live to say to his wondering grandchildren "I remember the *first* airmen who went around the world!"

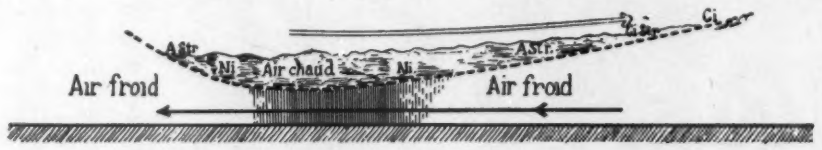
The writer did not see the first steamboat—the old Clermont under Robert Fulton—paddle up the Hudson River from New York to Albany; but as a boy he was told about it by one who as a boy had raced along the river bank on that memorable day in 1807.

The air flivver of to-day will resemble the air liner of 1950, about as much as the Clermont resembles the Mauretania.

Here then is a field of development for young engineers. Undergraduates now wondering where an opening may be found will do well to prepare themselves for the coming and as yet not over crowded profession of air engineer. They should know all that can be known concerning the structure of the air, that is, they must be aerographers as well as engineers.

Probably not one of the signers of the Declaration of Independence had the faintest idea of the composition of our atmosphere. I feel sure that not a single member of the Faculty at Technology or at any University in the land as late as 1905, knew that our atmosphere was a double shell affair, so to speak, made up of at least two concentric airspheres. In one, the lower, the temperature falls at a fairly uniform rate from the ground up to a height of 10 kilometers. Above this is a second airsphere, the *stratosphere*, in which the temperature does *not* fall with increase in altitude.

This was a remarkable discovery—and if a Nobel prize goes to one making a discovery of prime importance to mankind, surely a prize should have been given to the late M. Léon Teisserenc de Bort, a genial Frenchman of Scotch lineage who spent his means and in large measure his vitality sending up small balloons—*ballons*



IDEALIZED CYCLONE

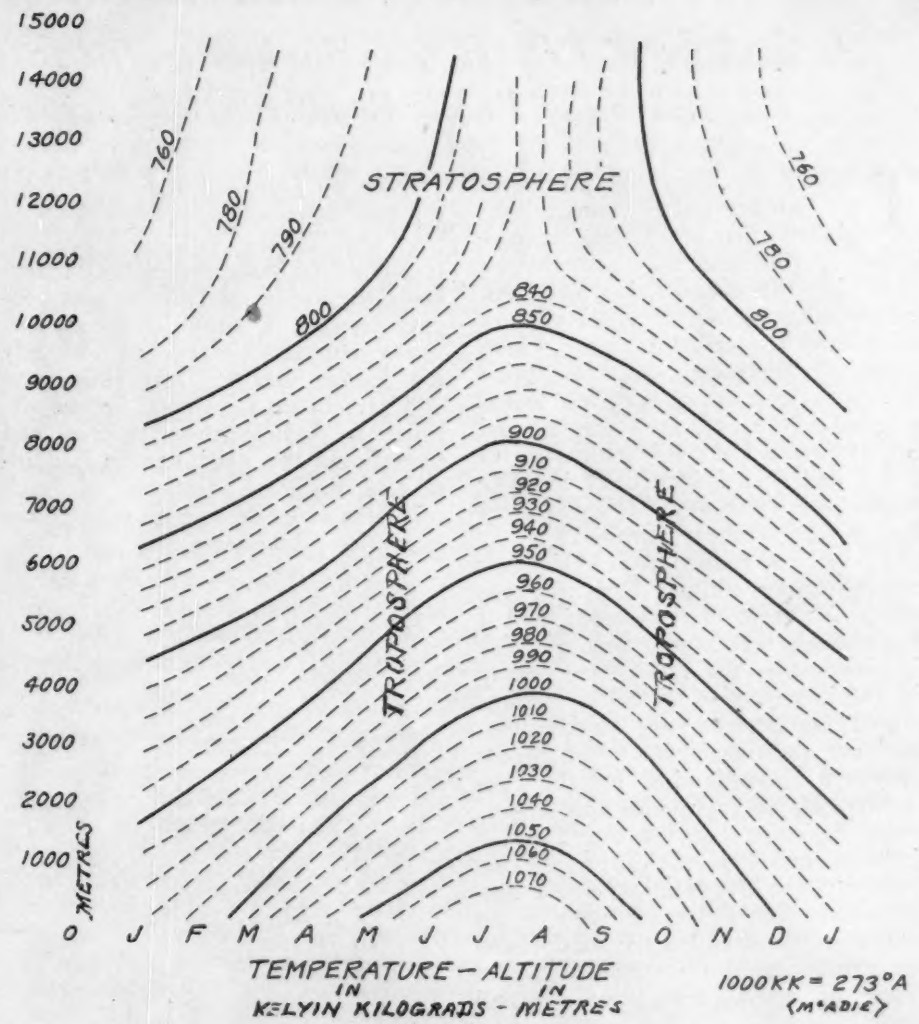
After J. Bjerkries and H. Solberg, as given in Mem. de l'Office Nat. Meteor de France, No. 6.

sondes—equipped with registering apparatus. In this process of sounding the atmosphere he had the cooperation of a young American aerographer, A. Lawrence Rotch, a graduate of Technology of the class of '84 and later Harvard's first Professor of Meteorology.

Teisserenc de Bort suggested the terms *troposphere* for the lower and *stratosphere* for the upper air shell. The upper zone was for a while called the isothermal region; but this name is not as appropriate as stratosphere. The terms advective and convective have also been suggested, the former for the upper shell because any interchange of air would occur chiefly thru horizontal motion, while in the lower there is almost continuous mixing of the air by ascending and descending currents.

The next remarkable discovery was that the height of the bottom of the stratosphere varied; being in the latitudes of Paris and Boston about 12.5 kilometers when anticyclonic conditions were present and only 10 km. when cyclonic conditions existed. The next step was to show that the height of the stratosphere varied with latitude. Thus near the equator, a sounding balloon shows a regular decrease in temperature up to 17 or 18 km., while at Boston the limit is reached at 10 or 11 km. In Arctic and Antarctic regions the *tropopause* or cessation of change in temperature is reached at 6 kilometers; and above the poles probably 4 km. The lower airsphere then bulges out considerably over the equator and is squeezed down at the poles. As a result we find that the lowest natural temperature thus far recorded is 667 on the Kelvin Kilograd scale. (In this scale the coefficient of thermal expansion of air or any gas under constant pressure is .001 instead of the awkward .00366 of the so-called Absolute scale. On the Kilograd scale zero is the absolute zero—and 1000 represents the freezing of pure water under standard conditions). On the old scales this temperature is —91.9°C, (181°A), (—133°F). This was recorded at a height of 16,440 meters. The balloon went much higher, in fact up to 26,000 meters but above and below the tropopause the temperature rose. This leads to the seeming paradox that the coldest spot on earth is in the upper air *over the equator* and not over the poles.

The discovery of this first and greatest inversion of temperature in the free air has been followed by a general reconstruction of our ideas regarding the origin of storms, the stratification of air masses, resilience



TROPHOSPHERE AND STRATOSPHERE. KILOGRAD SCALE OF TEMPERATURE

and penetration. It has also become evident that the old conception of a homogeneous atmosphere obeying the simple relations and laws of gases, as determined in laboratory practice needs considerable modification.

We have also found that there is a middle atmosphere, about 5 km. elevation, which is free from surface friction and therefore without the minor vortices and disturbances characteristic of surface air flow. In fact Sir Napier Shaw has lately given us the view that the atmosphere may be regarded as separable into many quasi-independent layers— the test of stratification beng potential temperature, or the temperature which the air mass would acquire if brought down to the surface, due to the variation of temperature with pressure. He sees even in the troposphere itself a succession of separate airspheres. These layers slip on another and do so without much loss or gain of heat. Water vapor is the real agency causing interpenetration. Shaw analyzes the curve of variation of temperature with height into sections depending on the departure of the lapse rate from adiabatic, both for dry and saturated air. When one stops to think of it, this is just what the clouds are trying to tell us. Perhaps the casual observer will never notice it; but a careful cloud observer even without the aid of a nephoscope will often see clouds moving in different directions, thus pointing clearly to thermal stratification.

Even if there were no clouds we know of the existence of air streams that not infrequently move in different directions. Occasionally we have a case where the currents seem to be almost diametrically opposed, as on December 2, 1925, when on the front side of a Florida hurricane moving northward, and at the time centered off the Virginia Coast, the surface winds to a height of 400 meters were from the East (90 to 110 degrees) with a speed of 12-15 meters per second (27 to 33 miles per hour) while at 1000 meters, the air was moving from the West by South (250 degrees) and with a speed of 6 meters per second (13 miles per hour).

So there are not only marked changes in direction but also in velocity within comparatively small distances.

(Continued on page 344)

A Study of Thin Brick Pavements

An abstract of a report on accelerated traffic tests and field studies by the Bureau of Public Roads especially prepared for T. E. N.

By L. W. Teller and J. T. Pauls
United States Bureau of Public Roads

THERE has been manifest lately a growing belief among engineers that brick less than 4 inches in thickness may properly be used in the construction of brick pavements. Advocates of the thinner brick have contended that the 4-inch depth is unnecessary, and that brick of 3-inch thickness or even less would give equally satisfactory results, and the extensive and satisfactory use of 3 1/2 and even 3 inch brick in some parts of the country has apparently lent support to the contention.

If such a reduction in thickness can be made without impairing the service value of the pavement, and if the manufacture of the thinner brick is practicable, the resulting economy in the construction of brick surfaces would doubtless be very considerable; and the question is one which merits thorough investigation on that account. If, as experience has apparently demonstrated, the 3 1/2 and 3 inch thickness can be employed successfully, the investigation should confirm that fact and go further to the extent of ascertaining the least thickness practicable from the points of view of manufacture, service, and cost.

Recognizing the importance of the question the Bureau of Public Roads has undertaken to conduct such an investigation, in the course of which it has made a field study of the service behavior of brick pavements in which brick of less than 4-inch thickness have been used, and concurrently an accelerated traffic test, at Arlington, Va., on sections of pavement built of brick of different thickness and a series of laboratory tests on the brick used to determine their quality. Several plants manufacturing brick of less than 3-inch thickness have also been visited to determine the attitude of the industry toward the use of the thinner brick and to ascertain if their manufacture presents any particular difficulties.

The Accelerated Traffic Tests

Accelerated traffic tests have been carried on at the Arlington Experiment Farm, Arlington, Va., during the last several months. Their object was to obtain data on the relative resistance to heavy-truck traffic of paving brick of the several thicknesses, and every effort was made, therefore, to eliminate all other variable factors which might influence the results of the tests, the only exception being the use of the two kinds of bedding course. Because of the opportunity afforded by the test to study the relative merits of the plain sand and cement-sand bedding, it was decided to include this feature, and accordingly the pavement as laid includes duplicate sections of each thickness of brick, one on each of the two types of bedding.

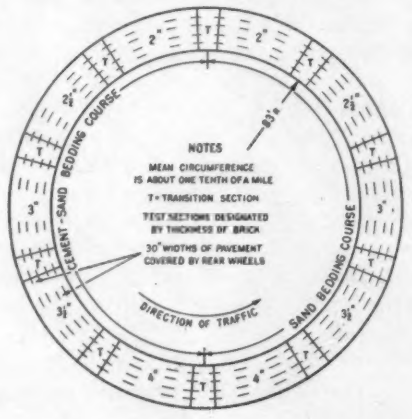


FIGURE 1

General Plan of Brick Test Track

In order to minimize the possibility of a variation in the quality of the brick used, they were all obtained from one manufacturer, and all are of the vertical-fiber, plain wire-cut, lugless type, 8 1/2 inches long and 4 inches wide, and depths for the several sections being 2, 2 1/2, 3, 3 1/2, and 4 inches.

A circular concrete base, which formerly had served in tests of bituminous pavements, was available and was used as a base for the brick sections. This base has a mean circumference of about 540 feet, is 13 feet wide, and at the beginning of these tests was in perfect condition.

For the purpose of the brick test this circular base was divided symmetrically into 10 equal sections. On one-half of the circle the plain sand bedding course was laid to a thickness of three-fourths inch; on the other half a 1:4 cement-sand course of the same thickness was used. On each type of bedding five test sections were constructed, one of each thickness of paving brick. Each section was about 45 feet long and between them the change of one-half inch in surface elevation made necessary by the change in thickness of brick was made in a transition section about 10 feet long.

This change in elevation was accomplished by adjusting the thickness of the bedding course over a length of about 3 feet in the center of the transition section, the bedding for this distance being stiffened by the addition of a small quantity of Portland cement.

On account of the difference in circumference between the inside and outside edges of the track, a "Dutchman" as shown in Fig. 1 was made in the center of each transition section.

After the brick were laid the pavement was rolled with a 3-ton tandem roller, and bricks which appeared to be damp were dried with a portable kerosene torch. This was followed by culling, after which the joints were filled wth a squeegee coat of asphalt of 32 penetration, applied at a temperature of 375° to 400°F. The pavement was constructed late in November and on account of the low temperature considerably more asphalt adhered to the surface of the pavement than was desirable. A light coat of sand followed the asphalt and another rolling completed the construction of the test pavement. All work was done by a contractor thoroughly familiar with brick pavement construction.

Before traffic was applied the various sections were marked off with radial painted lines, and longitudinal traffic lines were also painted on the surface in order that the truck wheels might be confined to a path 30 inches wide and thus accelerate the test.

The general plan was to apply 3-ton, 5-ton, and 7 1/2-ton motor-truck loads a definite number of times on each test section and to observe the results. The first phase consisted of the application of these loads with motor trucks equipped with solid rubber tires in good condition. The loads varied from 580 pounds per square inch for the 3-ton truck to 881 pounds for the 7 1/2-ton truck. In the second phase the trucks were equipped with heavy nonskid chains on the rear wheels and the loads applied were the same as in the first phase. In both phases the 3-ton truck made 10,000 trips, whereas the 7 1/2-ton one only made 2,200 in the

second phase as compared to 20,000 in the first one.

The base of the test track was originally constructed with superelevation for a speed of 9 miles per hour. It was thought that this speed was too low for representative traffic, and during the tests without chains a speed of 12 miles per hour was maintained. This caused a difference in pressure under the two rear wheels, the effect of which will be discussed later. During the second phase of the test it was found that the trucks could not maintain a speed of over 9 miles per hour without overheating because of the heavy chains, so this speed was used throughout this part of the traffic test.

Results of Accelerated Traffic Test

The results of the accelerated traffic test are expressed graphically in numbers of broken bricks for the 2-inch brick and in tabular form for the other thicknesses, in Fig. 3.

From a study of the graphs in Figure 3 it will be seen that:

1. Practically all transverse breakage occurred in the 2-inch brick sections.
2. Within the limits of the test, resistance to breakage by the 2 1/2-inch brick appears to have been but slightly less than that of the thicker brick.
3. Breakage in sections laid on sand bedding is less than half of that occurring in sections laid on cement-sand bedding.
4. The greatest amount of breakage occurred during the application of the 7 1/2-ton load with plain solid tires.
5. The greatest increase in breakage occurred during the first 10,000 trips of the 7 1/2-ton, plain-solid-tired traffic.
6. The rate of breakage greatly decreased under the traffic following completion of the 7 1/2-ton, plain-solid-tired traffic.

The high resistance to breakage shown by the 2 1/2-inch brick was one of the important results obtained from this test. The slightly better quality indicated by the physical tests can only partially explain the remarkable strength of this brick under severe traffic conditions.

The marked contrast in breakage occurring on the two types of bedding course strikingly demonstrates the superiority of the plain sand over the cement-sand bedding, at least for the heavy-traffic pavements.

The higher rate of breakage which occurred during the early traffic, as shown in Figure 3 is probably explained by variation in the quality of the brick. It is probable that there were in each section certain brick slightly warped or of poorer grade, and these, breaking under the lighter loads, would tend to increase the early rate of breakage.

Greater breakage occurred under the outer wheels in the tests made with plain solid tires. This is the condition previously referred to and attributed to the fact that the trucks when equipped with plain solid tires were operated at a speed of 12 miles per hour whereas the pavement was superelevated for a speed of 9 miles per hour. The greater load which, under this condition, would be thrown upon the outer wheel, is doubtless the cause of the greater breakage which occurred in the outer wheel strip under the plain solid-tired traffic. In the tests made with nonskid chains on the rear wheels the speed of the trucks was reduced to 9 miles per hour with the result that the breakage in the two wheel strips in this phase of the test was more nearly equal.

Condition of the Test Pavement After Completion of Accelerated Tests

Although the amount of transverse breakage has been taken as the criterion of the relative service of the several thicknesses of brick, it must be understood that the transverse breakage alone did not materially affect the condition of the pavements. The broken portions remained in position, and under the plain-solid-tired traffic did not ravel or scale at the cracks except in the 2-inch sections. The number of brick broken during the entire test was less than the number that would ordinarily be broken during the rolling of a brick pavement.

Figure 2 shows the condition of the several brick sections at the completion of the plain-solid-tired traffic; and it will be observed that the damage in all sections was practically limited to transverse breakage. Practically all the cobbling resulted from the operation of the traffic equipped with nonskid chains, and the greater part occurred during the early stages of this traffic. The spacing between the brick appeared to be a controlling factor in the amount of cobbling which took place. Edges of the cracks formed in broken bricks were rounded about the same amount as the original edges of the brick.

Very little difference was apparent between the condition of the 2 1/2, 3, 3 1/2 and 4 inch high sections after the chain-equipped traffic test. All sections were in almost perfect condition at the completion of the traffic test except the sections of 2-inch brick which showed marked effects of the heavy traffic.

Test Traffic Compared with Traffic On Actual Highways

It will be seen from the tonnage curve in Figure 3 that a total of 62,200 trucks passed over the 30-inch strips of the test pavements, that about one-third of these were equipped with the heavy nonskid chains, and that the total tonnage moved during the period of the test amounted to approximately 630,000 tons.

A quantitative comparison of the traffic applied to the test sections with the actual traffic using a few heavy-traffic highways is made possible by the studies previously made by the Bureau of Public Roads of the transverse distribution of truck traffic on paved highways of various widths. Using the data from these studies it is possible to estimate the maximum concentration of actual traffic on a strip of any given width in terms of a percentage of the total traffic. Applying these percentages to the known traffic on certain heavily traveled highways it is possible to approximate the maximum amount of traffic passing over a strip of these highways 2 1/2 feet wide corresponding to the width of the traffic lanes on the test track.

For purposes of comparison in this manner certain highways in Cook County, Ill., have been selected. It is interesting to note, therefore, that the traffic of trucks of the several capacities applied to the test track is equivalent to the corresponding traffic over these highways in periods of from 2 to 146 years. In terms of total tonnage the test traffic is equivalent to five years of traffic on the most

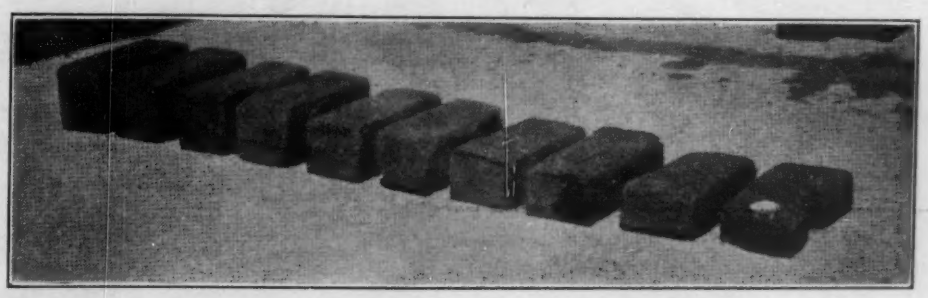


FIGURE 2

Brick of the different sizes taken from the test pavement after traffic. The group shows the extreme variations in the condition of the brick after the service tests.

heavily traveled of these important motor truck arteries.

An equitable comparison would probably be obtained were we to use the average of the truck traffic on the Cook County highway system. Compared in this way the traffic on the test sections is equivalent to the average traffic using all highways in the county in 18 years, and the test traffic of 6 to 7 1/2 ton trucks to be equivalent to the corresponding actual in 70 years.

To obtain a comparison of that portion of the test traffic equipped with chains with similar traffic on actual highways, it is necessary to make an estimate of the portion of the year during which such traffic passes over the highways. It is believed that by estimating the yearly duration of this type of traffic at two months, ample time is allowed to cover the most severe conditions. On this or any other reasonable basis of comparison it will readily be seen that the test traffic with chains was far greater than any that could possibly come on any actual highway during the life of the pavement.

The Results of the Physical Tests of The Brick

Physical tests of the brick indicate that the brick used in the test pavement were of about average quality, though some difference appears to exist in the quality of the different sizes.

Rated according to their moduli of rupture and crushing strength the test results indicate the order in quality of the different sizes to be as follows: 2 1/2-inch (best); 3 1/2-inch; 4-inch; 3-inch; 2-inch (poorest).

The rattler losses, on their face, indicate a different order; but it has long been recognized that for brick of equal quality but different in size, the comparative rattler losses are not directly proportional to the differences in weight. Engineers have recognized the injustice of specifying the same percentage of wear for different thicknesses, and have adopted, very generally, the practice of allowing some tolerance for the thinner brick in comparing their rattler loss with that specified for the thicker brick.

It is apparent that the loss in the brick undergoing the rattler test is more nearly a function of the total length of edge than of the weight of the brick. In view of the increasing use of the thinner brick, it would seem, therefore, that some modification in the standard rattler test should be made so as to make it applicable to sizes of brick differing from that of the original standard block. Until such a modification is adopted, however, it will be necessary to correct the observed losses for the various sizes of brick so as to convert them to a comparable basis.

A compression test was made on the brick taken from the test pavement after the completion of all traffic. In making this test it was hoped to correlate the result of this test with service behavior. By comparing the crushing strength of the different brick with their condition after the test, it was noted generally that good conditions both as to rounding and breakage were characteristic of the bricks giving the higher crushing results, while broken or badly rounded brick gave consistently lower values.

A striking point noticed in the data from the compression tests on the brick which had carried traffic was the consistently lower value obtained from this test as compared with the result of the same test on brick that had not been subjected to the heavy test traffic. It was first thought that this might be an indication of fatigue in those brick which had carried the heavy continuous traffic of the test. In order to obtain more data on this point, additional tests were made. At first, a series of check compression tests was run. These test data, although consistent in themselves, did not agree with those obtained in the former series of tests. It appeared that the difficulty might be, and probably was, due to the failure of the capping on the worn brick. Accordingly transverse bending tests were run on brick which had carried traffic and on those which had not and these results did not show the reduction in strength indicated by the compression tests.

Pavements in which brick less than 3 inches in depth have been in service for a considerable length of time are practically limited to portions of Texas, Louisiana, Oklahoma, and Nebraska.

(Continued on page 348)

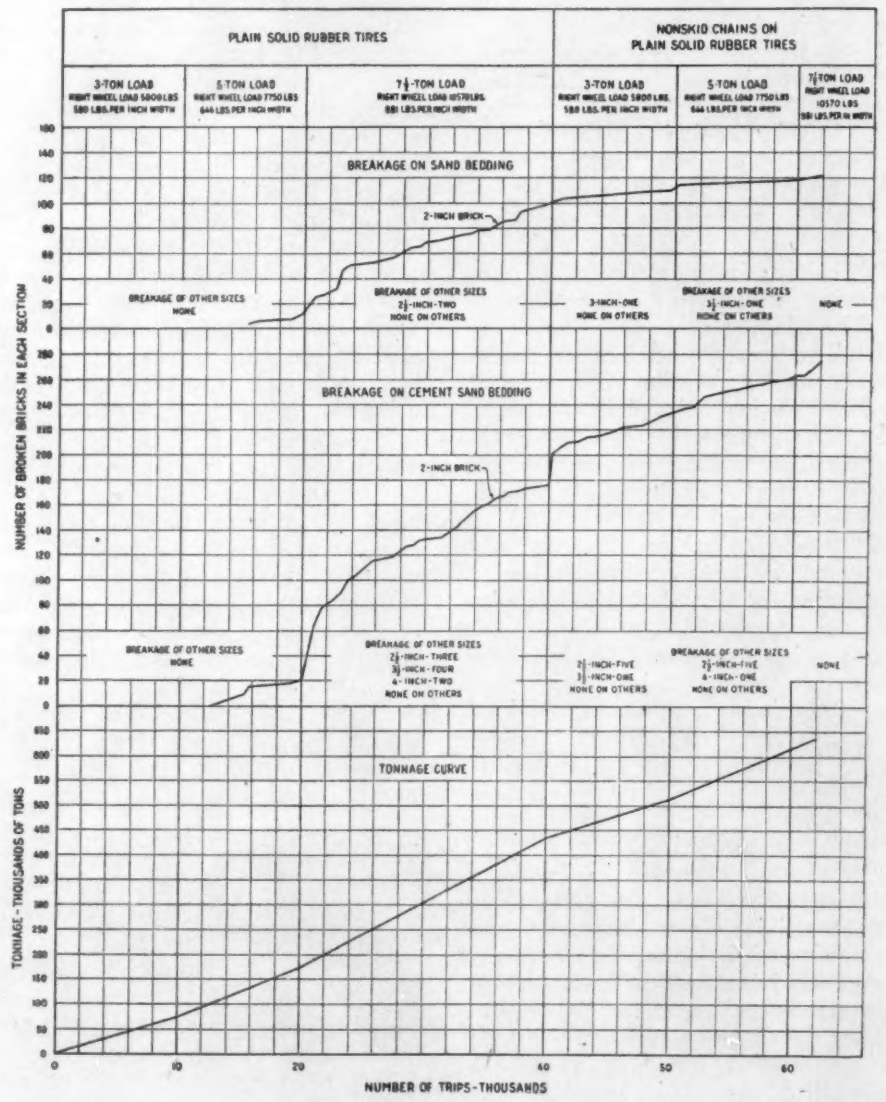


FIGURE 3

Results of the accelerated traffic test as measured by the number of bricks in the 30-inch wheel strips of each section, broken transversely under each load in the two phases of the test; and curve showing the tonnage to which the brick were subjected.

Welding All-Steel Automobile Bodies*

The new idea in mass production methods as applied to the great automobile industry

By J. W. MEADOWCROFT
Edward G. Budd Manufacturing Company

IF we were to turn back a score of years we should find relatively few commodities produced from light gauge sheet metal and that the method of fabrication then in use was almost exclusively riveting. Riveting as a means of assembly caused much difficulty. Rivets were not driven tight. The rivet holes were over or under size; rivets were not driven in line with the axis of the center line of the rivet, and there were numerous other objections which we need not dwell upon here. It was due to the above conditions that so much stress was laid on the importance of finding a method of fabricating sheet metal products which would be useful in the construction of such commodities and which would yield a more substantial and economical product.

Electric spot welding is the method which has replaced riveting, and this method of fabrication has been applied very successfully, because the welds are strong, the production is large, and all with lower cost and cleaner operation, and at the same time the capital investment in tools and the maintenance cost has undergone a notable reduction.

During the early days of electric spot welding sheet metal, much difficulty was encountered due to the failure of manufacturers of sheet metal to hold sheets to a uniform gauge. This gave the manufacturers of electric spot welding equipment the problem of building electric spot welding machines which would work by mechanical control in the switch, applying both power and pressure.

While this development work on welding machines was in progress, many steel mills were attempting to solve the problem of rolling sheets so that they could be held commercially uniform, which would then give us a material and a method of fabrication suitable for use in the construction of railroad coaches, aeroplanes, automobile bodies, etc.

In the design of an all steel body, much stress is laid on the design of the parts so as to secure the necessary rigidity into a minimum number of pieces so as to facilitate their ready assembly in the jigs and fixtures for welding. Welded joints and seams do not break open, nor do the metals wear upon each other, thus squeaks and noises are therefore eliminated. The assembled bodies are light in weight, durable, free from any defective joints and present an exterior surface smooth and free enough from imperfections to permit good finishing. Any surface irregularities, such as blow holes in seams or improperly closed joints, would act as a reservoir for the finishing material, and if enameled and brought up to 450° F., in a baking oven, would produce a blow or blister. The surface must be absolutely smooth, without depressions or cavities in which more than the standard thickness of enamel can flow, and so that the lacquers and color varnishes can be applied with the minimum amount of labor. A smooth unbroken surface eliminated puttying or filling up of crevices.

When designing the various parts which are fastened together much stress is laid on the method of welding to be applied, and a strict standard is adhered to at all times. The size and construction of the various types of bodies produced for the many automobile companies plays a very important part in the amount of welding used, but the average amount of welds on open type bodies is as follows:

1000 to 1100 electric spot welds
70″ to 80″ acetylene gas welding
10″ to 12″ metallic arc welding

On the full vision all steel sedan bodies, the average amount of welds is as follows:

1600 to 1700 electric spot welds
170″ acetylene gas welding
11″ to 12″ metallic arc welding

Development Of Special Devices Useful in Spot Welding

The various stampings are formed in dies and assembled in special electric welding machines, which have many special attachments. It is with the aid or assistance of these special fixtures that parts which have contours are held in the proper position while welding. It also insures safe and sound welds. This permits sufficient allowance at all times in the special welding fixtures for expansion and contraction which so frequently is a source of trouble in welding large bodies of metals together.

Considerable time is saved in handling and welding the parts as they are so assembled that sufficient welds are placed in a short time, permitting the production of large quantities of bodies on a small number of machines. Regardless of the method of welding used in connection with the assembly in the above machines, no time is lost in the manufacturing operations because each operator does his particular part, finishing with his helper or helpers within a specified time.

Another feature of economy in producing in these specially built welding machines is that the welding operators get the highest efficiency in the assembly and welding in the various parts of the body owing to the fact that the stampings or parts are interchangeable. Many operations are done on conveyors regardless of the method of welding used, this being done without any loss of time in the operation.

All of the various parts of the body are clamped together in such a manner that good contacts are assured in making spot welds. This is very essential in electric spot welding steel bodies, as it is necessary to spot weld the various sections of the body together so that the indentions in the metal are more or less eliminated. On some of the interior parts which are not exposed, the indentions receive no consideration, as it is not necessary to do any finishing work, but in all cases where welding is used, whether it be interior or exterior, whether parts are perfectly flat or shaped, we make the proper allowance as mentioned above for contraction at the point of welding so that the bodies are held in their proper shape and to their proper dimensions. This makes it possible for fenders and other accessories which are made to a correct shape, to be interchangeable.

Welding Personnel

Due to the tremendous amount of electric spot welding done in connection with producing steel automobile bodies, it is necessary to train a large number of men. In the training of men the qualifications of applicants for work as resistance welding operators which are of interest are as follows:

1. Age—18 to 25 years.
2. Height—Variable.
3. Weight—Variable.
4. Posture—Quick.
5. Hands, legs and feet must be in good condition.
6. Eyesight—must be in good condition.
7. Schooling—Grammar school at least.
8. Starting wage—
9. Length of training time.

*Delivered before the Fall Meeting of the A. W. S., Cambridge, Mass., Oct. 23, 1925.

The electric spot resistance welder welds on metal usually 1/16" in thickness. He must be able to adjust his machine in such a manner as to insure standard spot welds. The number of welds produced per machine per man when the machine is operated by hand or foot must average 10,000 to 25,000 spot welds daily, according to the size of the piece or pieces to be spot welded. Electric spot welding machines which are mechanically operated, produce 150 to 175 spots per minute. Men with mechanical experience or those who have worked around mechanical work are preferred. Electric resistance spot welding operators are more or less leaders in production, setting the pace for related operations, and it is essential that active, alert, and ambitious men be employed.

Instructions To Electric Spot Welding Operators

When electric spot welding apprentices receive their first instructions in the operation of electric spot welding machines, they are instructed very thoroughly as to the safety devices and tools required to be worn or used. A careful selection of clothing is made, for if an operator should wear an old torn shirt, coat, or any piece of clothing which is in any way ragged, it is apt to become ignited and cause a very bad burn. We strongly disapprove of the use of cotton garments, or those which contain a mixture of more cotton than wool, as the writer has seen a number of operators catch fire from sparks or flying molten metal, falling upon a fuzzy shirt or apron. The regular grade of blue woolen shirt commonly worn by workmen is about the safest garment that can be worn.

The operators wear an apron of leather which is of the proper size to protect him from a point high on the chest to the knees, and well around the waist towards the back. The operator is instructed to wear his apron at all times and not permit it to become oily or oil soaked without either having it washed or replaced with another apron.

Much stress is also placed on the selection of goggles. We have found that they should be so constructed that they are adjustable for the proper distance between the eyes, and it is also necessary for comfort that the temples or the part which is used behind the ear, should fit properly. The goggles should be well ventilated, but at the same time they should have the side shields and they must be so adjusted that there are no crevices around the outside edge for the sparks or molten metal to enter between the face and the goggle.

After the apprentice is equipped with goggles, apron, and the proper clothing, he is instructed as to the various parts of the electric spot welding machine and their use. He learns how to prepare a die or electrode, and to assemble them into water shank or die holder. After the dies or electrodes are assembled in the die holders, the apprentice is instructed how to adjust the electrode holder so that the upper and lower electrodes or dies are placed in alignment. He is also impressed at this time with the fact that he should never strike an electrode or die with any hard substance to place them in alignment, as the copper is soft and the threads are apt to become loose, resulting in a leak.

The apprentice then receives instructions on the following:-

1. How to attach special accessories to electrodes, so that they can be used on two or three welding operations.
2. How to file electrodes or die points to the proper diameter to correspond with the gauge of metal to be welded.
3. What action to take when the electrodes become hot in operation.
4. The proper care of the locks on the water shank holders using the proper size wrench to lock water shanks or electrode holders in same. Under no consideration is the operator permitted to use a wrench on a lock nut which is not properly fitted for the part.
5. What action to take when threads on electrodes begin to wear.
6. Why he should never use dirty and blunt dies.
7. Why the regulator switch should never be changed while in the operation of welding.
8. Why no material of any kind should be placed on transformer in electric welding machine.
9. Why water tubes should always be placed 1/4" from the end of electrodes.
10. Why no attempt should be made to weld rusty or scaly material.
11. Why it is necessary to have the water shank holders held firmly in water shanks.
12. Why he must watch connecting wires on switch.
13. How to assemble contact plugs.

The six basic causes which make repairs to electric spot welding machines necessary:-

a. Insufficient or improper lubrication.
b. Presence of dirt on bearing surface.
c. Misuse of machine.
d. Imperfect adjustments.
e. Vibration.
f. Unavoidable wear.

He is instructed the proper supervision of machines as to the systematic inspection which takes care of the first four causes—lubrication, dirt, misuse, and adjustments. As each man finishes his training, he is placed in one of the assembly departments under the supervision of one of the welding foremen, who is responsible for the quality and quantity of the work turned out by the apprentice. The apprentices are advanced from time to time in accordance with their ability to do higher class work, and as all operators are paid in accordance with the class of work they are doing, there is always a goal to work for, which obtains the best results for both parties.

The time study of welding operations is done by men who are thoroughly familiar with welding operations. They see that the operations are so separated that they can be performed in a highly efficient manner. Each and every operation is inspected, which means that the accuracy of the previous operation is assured. The inspectors are also men who have had more or less training in the art of welding, and at various time periods they make inspections of welds while they are being made, instead of after the welds are finished. By handling the inspection of welds in this manner, the inspector not only holds the quality of the welds to a high standard, but assists the welding operator regardless of the operation, to become more efficient in obtaining a production output satisfactory in both quantity and quality.

General Observations On Spot Welding Practice

When two metal sheets are spot welded together in accordance with the customary practice, the fusing of the metal and the pressure applied results in the formation of a low spot weld. The thickness of metal at the weld is slightly less than the combined thickness of the two overlapped sheets in an unwelded portion. This difference in thickness is not very great, but where a finish is to be applied to the surface of one of the sheets, it is objectionable since these low spots give an undesirable appearance to the finished surface. To overcome this difficulty it has been the practice to eliminate these low spots by grinding off the surface so as to bring it down to the same level as the weld. This practice is slow and costly, but heretofore it has been necessary in order to

(Continued on page 334)

Purdue's Personnel System

The purpose and function of the system at this University as published in the Purdue Engineering Review for November 1926

By J. E. WALTERS
Director of Personnel, Purdue University

TO develop the personality and character as well as the mind and body of the students of engineering is the chief purpose of the personnel system of the schools of engineering of Purdue University. It is difficult for the student to know his own faults, to see himself as others see him. He does not often know what others find objectionable about him, and without a knowledge of his objectionable characteristics he will be handicapped through life. The personnel system endeavors to give the student an idea of what is objectionable and what commendable in his personality.

The purposes of the personnel system may be stated briefly as follows:

1. To assist the student in the improvement of his personality and character.
2. To study and analyze the vocational fitness of the student by means of interviews, by consulting the judgment of members of the faculty and by the use of personality ratings and general information.
3. To assist the members of each graduating class in engineering to secure employment.
4. To assist all graduates of the university to obtain and keep satisfactory positions.

By the time a student is a senior, the personnel staff and the members of the faculty have an intimate idea of the student's possibilities, and can assist in recommending to an employer the men best suited for a particular type of work. Their recommendation assists the employer in obtaining the best man as well as in getting the graduate properly located. The graduate will be more satisfactory when engaged in work for which he is best suited and where promotion will follow most rapidly. The employer will be spared the cost in time and money of having to experiment in order to find out where the college graduate would best fit into his organization. The personnel system was started by Dean A. A. Potter in 1920, and he is responsible for maintaining it from that time. Mr. W. S. Von Bernuth was personnel assistant to Dean Potter from 1922 to February 1926.

As soon as the freshman arrives at Purdue University, complete general information concerning him, his family, and his experience is obtained, and a record started. In the latter part of the freshman year, reference blanks are filled out by each freshman. He gives the names of fifteen or more people who know him best—five teachers, five students, and five others who are qualified to rate him on the characteristics of his personality: Address and Manner, Attitude, Character, Co-operative Ability, Disposition, Industry, Initiative, Judgment, Leadership, and Native Capacity. Rating blanks are then sent to the fifteen references. A copy of the rating blank is given herewith.

The ratings are made in comparison to men of similar age, educational preparation and environment. The fifteen ratings (or opinions) are averaged so that prejudices of one or two will not greatly affect the total average. The rating scale used ranges from one to ten. There are five general classifications; poor, low, average, high, highest. High average is six; low average is five, average is between five and six; poor is one; highest is ten, and so on, as the characteristic is known to be. The rating scale of one to ten is used as students customarily think in tens.

As soon as the fifteen people rate each student on each of the ten characteristics, the ratings are compiled and recorded on the personnel card. The general impression of the student's personality can readily be seen from the ratings. The procedure is repeated in the junior year.

If the ratings in the freshman year on any particular characteristic, or all of the characteristics, are low, the student is called into conference by the personnel director or a member of the staff and asked why he is low in that particular characteristic or why he has impressed fifteen as being low in that characteristic. The matter is discussed with him and a method of improvement is pointed out. Then after the junior rating, if the characteristic is not improved, he is called in for another such conference. Finally, during the senior year he has another opportunity to improve. As soon as the data from the references of the junior reach the personnel office and are compiled a careful study is made of the ratings and the opinions are again averaged. The freshman and junior ratings, a composite of grades, health record and general and all other information are put on the student's personnel record, a reproduction of which accompanies this article.

After graduation and after sufficient time has elapsed to give ample oppor-

(Continued on page 342)

(Personnel Form No. J—15M-5-26)

Characteristics	Poor 1	2	Low 3	4	Average 5	6	High 7	8	Highest 9	10
1. **ADDRESS AND MANNER:** (Does he leave a good impression? Does he talk well? Is he popular? Has he a good bearing?))										
2. **ATTITUDE:** (Is he rational, agreeable to reason, in his views? Interested in his work? Optimistic? Self-controlled?)										
3. **CHARACTER:** (Is he reliable? Dependable? Absolutely honest? Responsible? Clean? Just? Courageous?)										
4. **COOPERATIVE ABILITY:** (Can he work with others? Is he accommodating? Loyal? Willing to learn? Tolerant? Tactful? Is he a good mixer?)										
5 **DISPOSITION:** (Is he cheerful? Courteous? Congenial? Enthusiastic and not conceited?)										
6. **INDUSTRY:** (Is he a hard worker? Has he perseverance? Is he persistant?)										
7 **INITIATIVE:** (Is he a self-starter? Does he recognize, start and develop opportunities to a successful conclusion? Is he original?)										
8. **JUDGMENT:** (Has he common sense? Observing and reasoning power? Foresight? Resourcefulness? Does he know values and the relations of things? Is he practical?)										
9. **LEADERSHIP:** (Does he understand men and can he command their respect? Has he executive ability? Does he precede and direct men?)										
10. **NATIVE CAPACITY:** (Is he naturally accurate, systematic, bright, alert? Has he an inherent knowledge of facts and data? Can he concentrate? Does he learn readily? Has he a natural aptitude for work?)										

TRY THIS ON YOURSELF !

Place a check mark (v) after each characteristic at the place on the scale that you know yourself to be qualified to be rated. If you are exceptionally good put a check under 10. If you are poorest put it under 1. If average place check between 5 and 6.

Grade yourself in comparison to men of similar age, educational preparation and environment. An effort has been made to define each of the characteristics in the above list in order that greater uniformity of rating may result.

The Pictorial Section

Illustrated review of automotive developments of the past year

THE present year will be remembered by those who follow the trend of automotive design as one in which a great deal of refinements were made in an already efficient and dependable mechanism. The automobile of 1927 represents a great deal of research in all fields of science and as such, is of interest to all engineers and scientists.

The engines of today are especially interesting as more power is being obtained from the same fuel than was ever before accomplished. Most of the cars of today are using the Ricardo type combustion chamber in which a very high degree of turbulence is secured. According to Mr. Ricardo, the power and efficiency of an engine may be increased 20% by merely adopting this form of cylinder head. The combustion chamber in this arrangement is designed to have most of the clearance space over the valves and very little over the piston. Examples of this appear on the accompanying pictorial pages. Engines using this combustion chamber are able to have a higher compression ratio which raises the power developed.

This year also marks the appearance of some more eight cylinder cars. The New Marmon is a very good example of a well designed light eight. The engine has a displacement of 190 cu. in. and develops 64 horsepower. Its dimensions are 2 3/4x4 in. with a compression ratio of 5.27 to 1. This high compression ratio is an example of the trend towards higher thermal efficiencies prevalent in all designs of this year. The cooling systems of all the cars have been planned to eliminate hot spots which help to make high compression possible.

Vibration has been studied and practically eliminated from most cars. Reciprocating parts have been lightened by using aluminum pistons with invar struts on such cars as Marmon, Chrysler, and Packard. These pistons are very light and still have ample strength. Because of the higher thermal conductivity of aluminum, the pistons have a lower temperature which also helps to reduce hot spots in the combustion chamber. The invar struts enable the pistons to be fitted to close limits without great allowance for expansion under operating conditions. The connecting rods of some cars are now being forged from duraluminum which has a great deal of strength and is still very light.

Many of the new cars have adopted ventilating systems for the crankcase similar to that introduced by Cadillac some time ago. These help to minimize the bad effects of crankcase dilution. Buick, Oldsmobile and others have adopted this feature. Most of these cars also use a filter to remove any solid material from the oil. Air cleaners are fitted to most carburetors which remove dirt and grit from the air supply to the carburetor. Removing this dirt helps to minimize carbon deposits and also prevents scouring of the cylinder walls. These improvements in the lubricating system and air supply have greatly lengthened engine life. As engines were built to develop more power and rotate at higher speeds lubricating systems had to be improved to supply the right amount of oil to all bearing surfaces. Marmon has always had an especially good system and now in the eight has taken an added precaution against injuring the cylinder walls when starting. On the Marmon eight a special means is provided to supply oil to the cylinder walls while the starter is depressed.

One of the more radical innovations of the year is the introduction of the single sleeve engine to the American motoring public by the Continental Motors Corporation. This engine has been used abroad with a great deal of success and holds great promise to American designers. Another European development which has been used on American racing cars in the past year is the supercharger which enables the cylinders to be completely filled with an explosive mixture regardless of speed and atmospheric conditions. Superchargers still present many mechanical problems due to the very high speeds of the rotor. It is probable, however, that at least one American car will be on the market before 1927 draws to a close equipped with a supercharger. The German Mercedes has been so equipped for some time with very satisfactory results. The engines as a whole this year represent the highest possible type of engineering.

After the engineers eliminated vibration from the engine as a unit, they took steps to cushion the engine in the frame. A great many cars now support the engine on rubberized fabric blocks which prevent the transmission of vibration to the car and of shocks to the engine. Rubberized fabric blocks are being used in place of the conventional spring shackle in the Marmon eight and several other cars to eliminate rattle and wear at this important point.

Along with the development in engines, steps have been taken to improve the rest of the chassis. A great deal of attention has been given to clutches and transmissions to insure ease and quietness of operation as well as durability. Gears are being made very accurately and of thoroughly heat-treated material. When the engines were finally balanced attention was given to the balancing of other rotating parts with large moments of inertia such as the clutch and in some cases, even the propeller shafts.

The Buick Company now balance the wheel with its tire and rim mounted in order to completely counteract any unbalanced force due to the tire valve.

Most of these improvements have been made to secure more pleasant riding conditions. A great deal of work has been done on spring suspensions during the past few years. The new Marmon and several other new cars are appearing with a very high ratio of total spring length to wheelbase. This makes for easier riding and greater durability. The semi-elliptic spring is by far the most popular at the present time.

The platform type of spring has completely disappeared, being supplemented in the Cadillac, the only car which used it in recent years, with a ball and socket type of shackle.

Much interest was aroused last year by the appearance of the Stutz with a worm drive in the rear axle. This has since also been adopted by the Stearns Knight in their new six-cylinder car. The main advantage claimed for this type of final drive is that it permits the overall height of the car to be considerably reduced.

During the year, several cars have been announced in which Gleason hypoid bevel gears were used in the rear axle. These gears also reduce the overall height of the car without sacrificing road clearance. Packard and Marmon are two examples of this type of design.

Four wheel brakes, balloon tires, and steering gears have all been developed considerably during the past year. Four wheel brakes are now being used by almost the whole industry. Lincoln, Hudson and Packard have all adopted the Bendix Perrot self-energizing type of brake which is by far the most satisfactory type. Steering gears have been better designed to eliminate the very objectionable wheel wobble and shimmy prevalent in a great many cars. The Marmon Com-

(Continued on page 350)

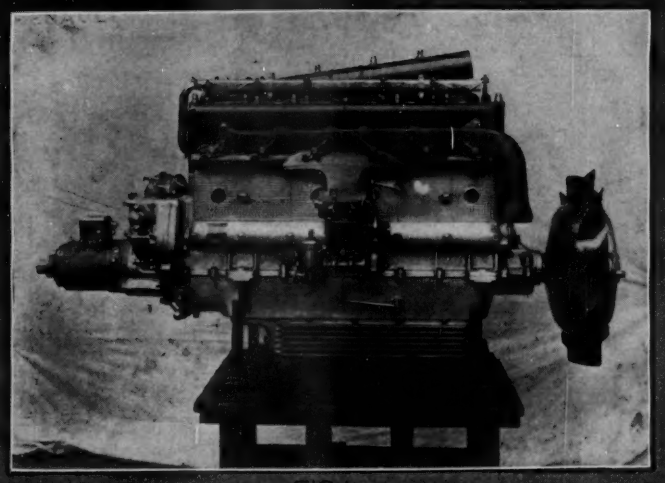


FIG 1
RENAULT 6 ENGINE

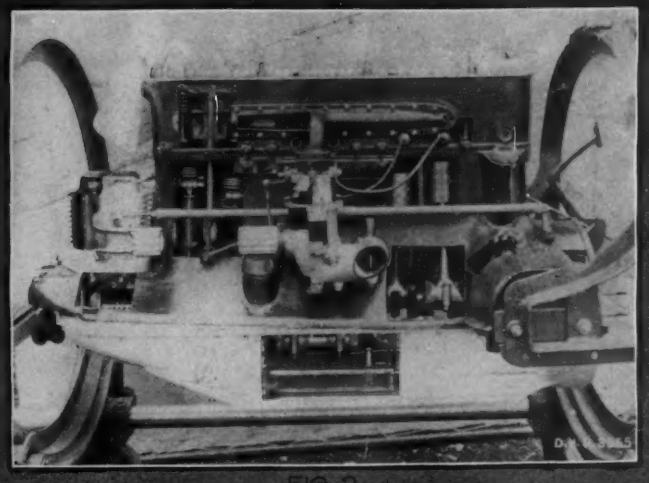


FIG 2
MERCEDES WITH SUPERCHARGER

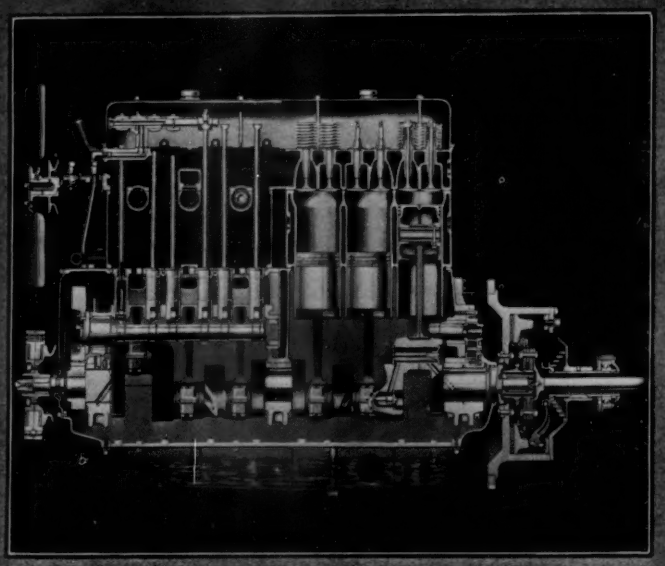


FIG 3
CROSS-SECTION OF MARMON 6

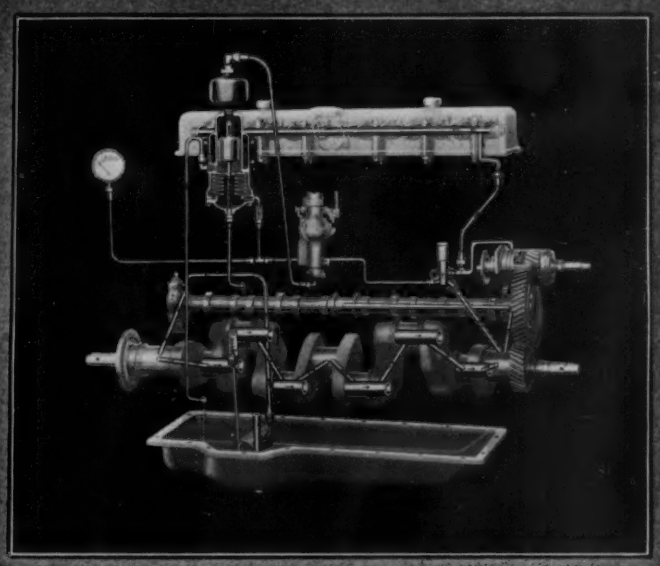


FIG 4
LUBRICATING SYSTEM OF MARMON 6

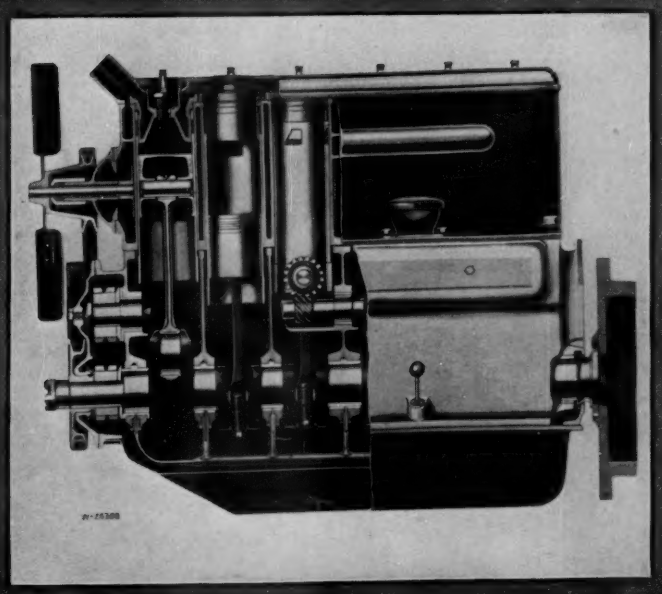


FIG 5
CONTINENTAL SINGLE SLEEVE 6

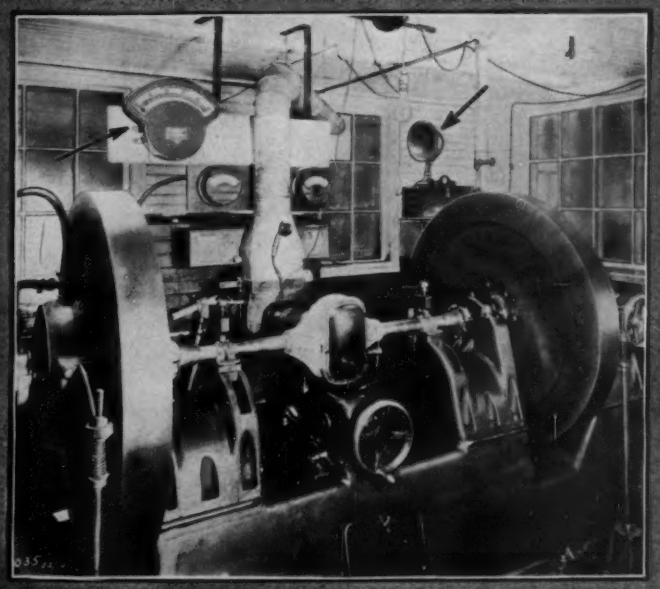


FIG 6
TESTING FRANKLIN AXLES BY RADIO

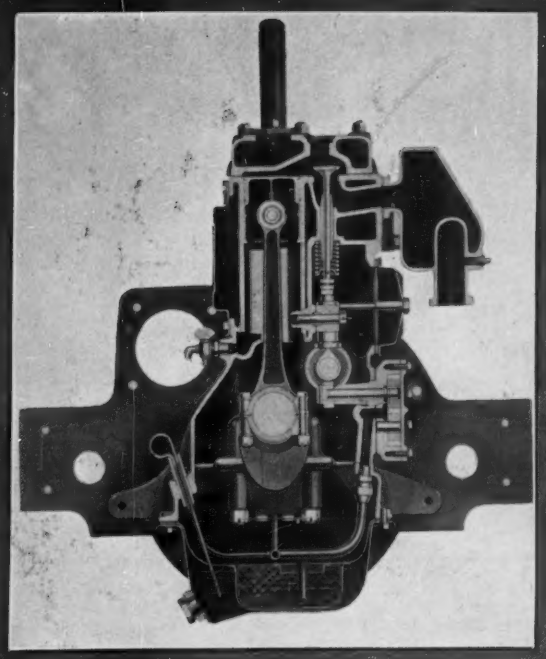


FIG 7
CROSS-SECTION
OF ERSKINE
ENGINE

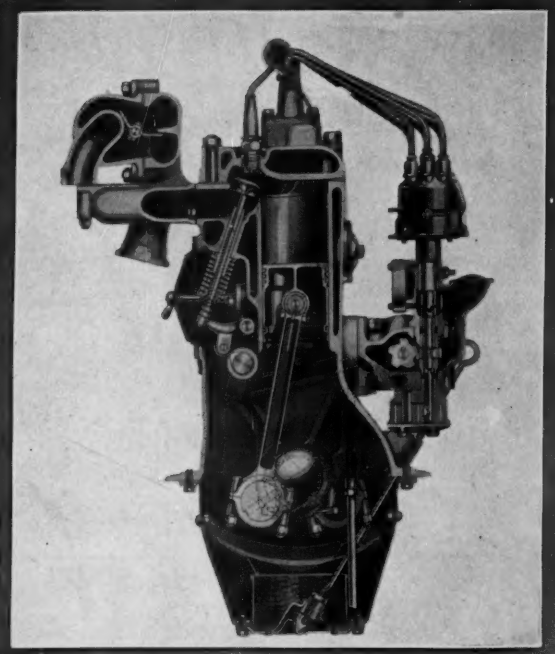


FIG 8
CROSS-SECTION
OF STUDEBAKER
ENGINE

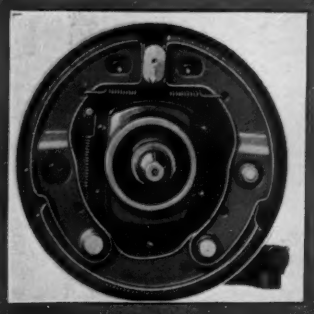


FIG 9
OLSMOBILE
FRONT BRAKE

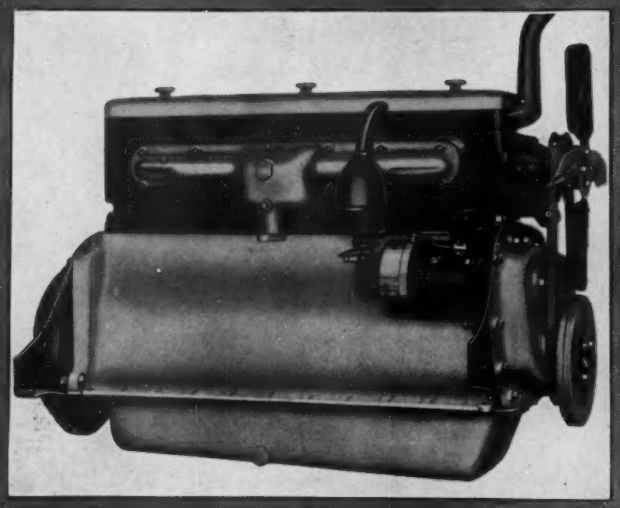


FIG 10
CONTINENTAL SINGLE SLEEVE 8

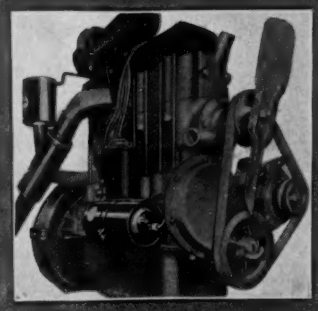


FIG 11
CHEVROLET
AIR CLEANER
AND OIL FILTER

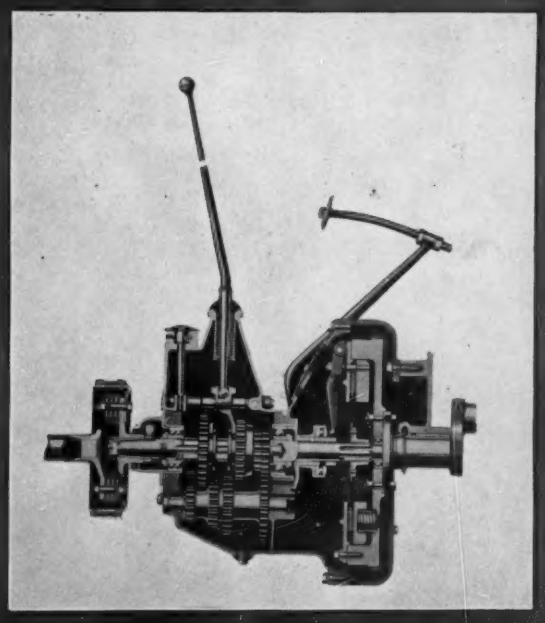


FIG 12
STUDEBAKER
GEARSET

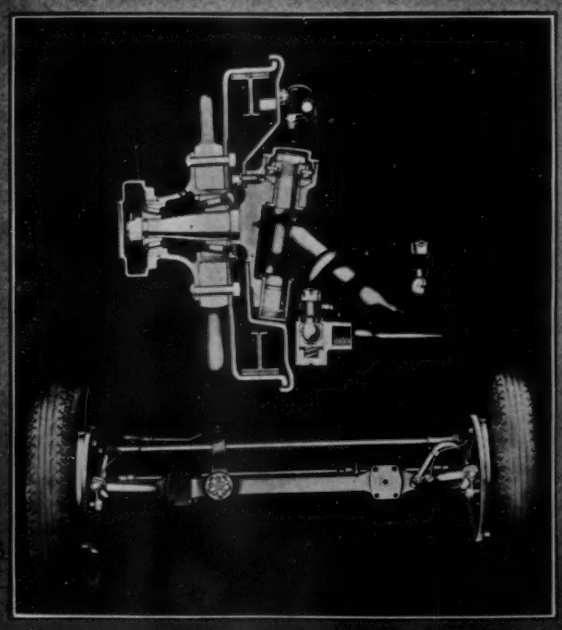


FIG 13
MARMON 6
FRONT AXLE

Editorials

PERSONNEL SYSTEMS

An article appears in this issue which deserves special mention on the Editorial Page—"Purdue's Personnel System" by J. E. Walters, and we wish to call it particularly to the attention of our readers.

Some work of a similar nature has been attempted from time to time at M.I.T., but in these isolated cases the emphasis has been placed largely on direct, if kindly, criticism from superiors.

Although there are certain phases that could perhaps be improved upon, we believe that Purdue's system has much to recommend it, and we feel that it would make an excellent basis for a similar system to be used at our own institution. A study by competent men would give much that would be helpful in improving the character of the young engineer.

We realise of course, that there is much to be said on both sides of the question. Many feel that this educational activity does more harm than good, and the requirements for Personnel Director are most exacting. However, experiments in other schools and in some of the fraternities would seem to indicate that much can be done with young men.

We earnestly recommend this plan to the attention of our august faculty for their perusal and experimentation. It seems to us that much more could be gained by such a study than with the alarming psychology tests to which each incoming class has been subjected.

Subsequent numbers of the "News" will have more to say on the subject.

MATER

We would like to suggest that the old-time-worn phrase Alma Mater which has for such a long time failed to express the true situation should be replaced by a more expressive one —Stabat Mater—or sorrowing mother! We would add to the already long list of her sorrows the latest vagaries of the sons of fair Harvard in the persons of the Junior debating team. These gentlemen recently argued the affirmative on the question: Resolved that there is more to be feared than hoped for from Science.

IN RETROSPECT

With this issue, the present Managing Board of "The Tech Engineering News" goes out of office. It behooves those of us who have guided the policies of this volume to scrutinize our work in an attempt to ascertain whether or not we have contributed successfully to the service of our professional magazine.

It is impossible to ever really forget the mistakes or disappointments, the disillusionments that out of necessity sprinkle our journalistic experience, and yet there has been so much that has been pleasant and of real worth, both in the work itself and in its associations, that it is not without real regret that we make our final bow.

THE COVER

The original of the sketch reproduced on the cover of this month's TECH ENGINEERING NEWS is another from the collection "Boston—Its Byways and Highways" by John Albert Seaford. It is a drawing of Boston's lone skyscraper, the Custom House Tower, in 1914 during the process of erection. The municipal building laws governing the height of construction have no authority over Federal buildings and the prominent landmark is the result. The Tower is Boston's nearest approach to the stupendous engineering achievements now in vogue in the tall buildings in New York and the middle West.

In this volume, we have attempted to increase the understanding between the Institute and its alumni, actual and potential, by the inauguration of a new feature page "Department Notes." It is, of course, really too early yet to know with certainty the value of this experimental contribution. We do feel, however, that the need is there, and that the "News" is the medium best suited to fill the need.

We have modified the presentation of our News Notes from the excerpt to the abstract type with the consequent gains both to the readers and to our own staff.

We have changed the rules governing our selections of the illustrations for the cover from the old idea that the cover must illustrate one of the articles to the new that the illustration should deal with an engineering subject, not necessarily definitely related with the content of the magazine, and should be as good as possible from the point of view of artistic attractiveness. This has been more difficult and yet we have not been entirely unsuccessful. The new volume promises much with the possibility of entire change in cover design.

We have permitted ourselves to indulge in the luxury of more or less specialized numbers, with the Railroad, the Marine, the Power and the Automotive issues based largely upon our new pictorial section, but at the same time we have tried not to overdo the specialization, and to include in each issue sufficient material so that there would be something of interest to each one of the readers. This has necessitated an appreciable increase in the size of the individual numbers.

We have defended the "Here and There" page from its attackers, who have sometimes become quite rabid on the subject, and continued to run it in spite of its occasional anemia. We feel that the human interest stories of a nature similar to those of the triumphs of the engineers at Keokuk, the traditions kept in firing the ovens of the gas companies and the stories submitted in this issue from the Little Laboratories should have a real place in the life of the young engineer, and permit him to talk about his own profession in lay society without the danger of boring his listeners.

We believe that we appreciate the values of illustration and have endeavored at all times to increase the "picture space," within the sanction of the budget, and at times persisted even with threats of immediate physical annihilation.

We have attempted to present both technical articles and articles of general scientific interest, but we have wished to avoid technicality for its own sake, trying always to keep in mind what we believe should be one of the chief aims of every professional journal of an under-graduate nature, that is, to interest and sustain the interest of the engineering student in engineering. In this, the attitude of the two lower classes forms the serious problem, their work seems so far removed from what they hope and expect to do upon graduation. Therefore they have received special consideration.

And finally, for those who have honored us with their attention to the Editorial page, we have attempted to keep these columns clear of the uninteresting, but all too prevalent, boiler plate type of editorial.

Just how far we have succeeded in improving the magazine is another question, but we feel that Volume VII has contributed its share towards increasing the service of the "News,"—and to all those who have been its readers during the past year,—Hail and Farewell! May the paper deserve your support to an even greater degree in the years to come!

The Engineering Field

Abstracts from the leading professional and trade journal

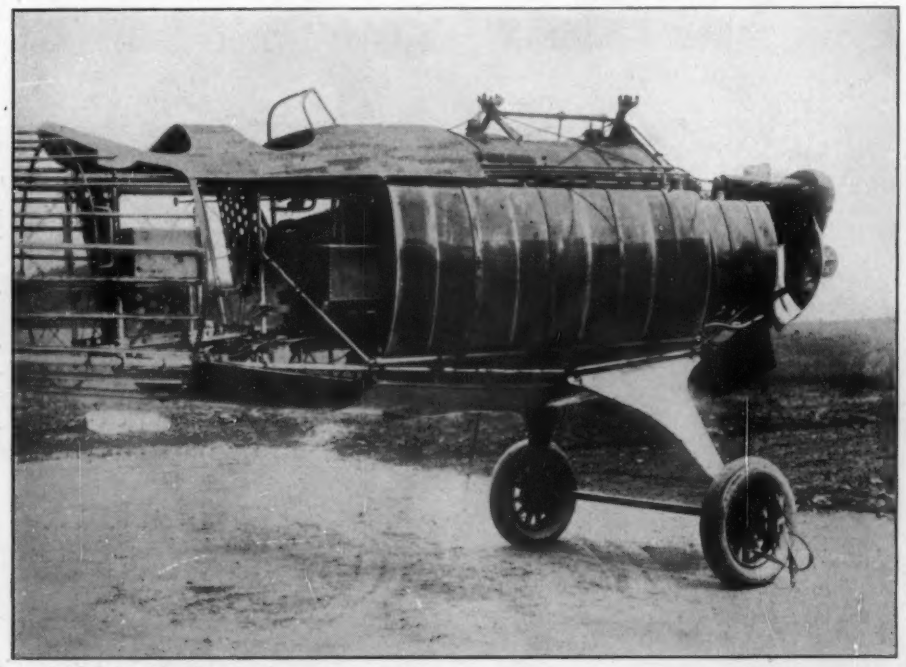
An Automatic Welder with which the operator needs but to push a button to produce a smooth weld with great speed and accuracy has just been placed on the market. This new machine starts the arc by touching the electrode to the work and then withdrawing it, after which the arc is maintained at constant length by feeding the electrode wire at the same rate that is fused into the weld. The wire is fed by means of a set of rollers geared to a constant speed motor through a magnetic clutch. The pressure and space between the rollers can be varied and various sized nozzles inserted in the welding head so as to adapt the machine for use of wire ranging from 2/32 inch to 1/4 inch in diameter.

The rate of feed of the wire is controlled by a selective gear shift on the rollers and by a finer adjustment obtained by means of a rheostat in series with the field of the motor. The welding head is so constructed that the electrode can be fed at any angle to the work. Provision is made so that the electrode is fed to or from the work automatically so as to adjust itself to any irregularities in the surface of the work. It is claimed that this machine is more accurate and faster than the most skilled hand operator, especially when used on a regular production schedule.

Fire Extinguishers employing carbon dioxide as one of their elementary materials or products have been in common use for some time, but devices using liquid carbon dioxide for this purpose are a recent innovation. A distinctive feature of the apparatus is a siphon tube which extends to the bottom of the supply cylinder and allows the liquid carbon dioxide to be forced out rather than to issue as a gas. Special valves provide for the release of the gas and spread it over a large area to obtain the greatest efficiency. Since the ratio of expansion is one to 500, it can be readily seen that a high pressure is immediately available.

The effect of the extinguisher is to not only check combustion due to the lack of oxygen, but to produce a chilling temperature brought about by the rapid expansion of the gas. Thus the fire is attacked in two ways. Since the use of liquid carbon dioxide is free from the usual damage which accompanies the use of other devices and materials, there is a decided advantage in its use around electric power installations which might be short circuited and severely damaged by extinguishers containing water.

Liquid carbon dioxide protection is highly adaptable to marine use, particularly in cargo holds and on tankers. It is remarkably efficient in combating oil fires, extinguishing them in 30 seconds with absolute dependability and no damage whatever, even though there may be considerable windage about an open tank. Since liquid carbon dioxide does not deteriorate, periodic renewal of chemicals is unnecessary. This fact alone should make the 35 pound portable extinguisher recently produced exceedingly popular, and also adds another point in favor of the permanent installation systems which are similar to the various sprinkler devices now on the market.



Copyright Scientific American

THE BREGUET PLANE

A view of the huge tanks which have a capacity of 800 gallons and are located in the fuselage.

Single Sleeve Valve Engine. A new type of automobile engine has been developed using a single sleeve valve. This sleeve is moved up and down and partly turned at the same time so that the proper ports in the sleeve and cylinder are connected at the right time. Lubrication is uniform because of the twisting motion of the sleeve valve.

This engine is more silent and shows higher operating efficiency than the ordinary type. It also weighs about 50 lbs. less than an engine of the poppet valve type. After a test run of 1000 hours, no wear was discernible on the surface of the sleeve.

The Breguet Plane. Captain Girier and Lieutenant Dordilly of the French Air Service have just completed a 2,920 mile flight from Paris to Omsk, Siberia in a standard type Breguet plane. Their average speed for 29 hours of flying time was 100 miles per hour.

The plane weighed 8,600 pounds, and had a loading of 14.6 pounds per square foot for each of its 590 square feet of wing area. The useful load was 5,500 pounds or 64.5 per cent of the total weight as compared to 50 per cent for the average plane. A 12 cylinder Hispano-Suiza engine which developed 450 horsepower was used. Therefore the power loading was 19.1 pounds per horsepower as contrasted to only 9 pounds per horsepower for the average mail plane.

The fuel tanks which have a capacity of 800 gallons or enough for 3,720 mile flight under favorable conditions were located on both sides of the fuselage.

Although the plane was so heavily loaded and no auxiliary devices were used, the plane made a perfect getaway and no trouble was experienced in climbing.

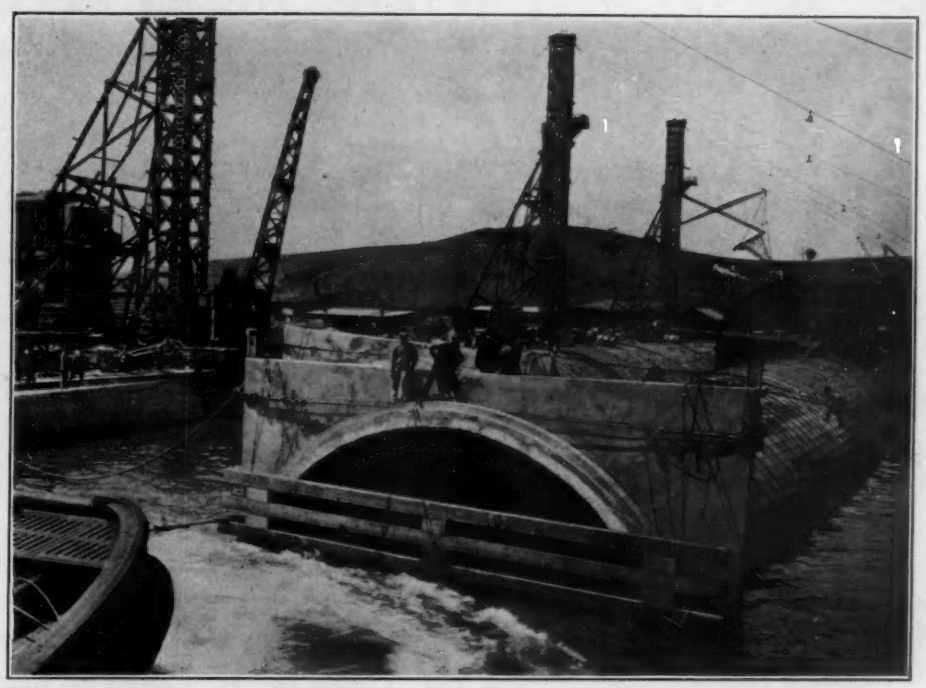
The New Vehicular Tunnel now being built between Oakland and Alameda, California, contains many unusual features of decided interest to the engineer. The tube is to be built beneath the estuary which lies between the two cities, with a length of about 2400 feet under water and long underground approaches at either end.

The subaqueous section is made up of twelve cylindrical concrete sections, each 203 feet long and 37 feet in outside diameter. When it is remembered that the Holland tunnels under the Hudson River at New York are only 29 1/2 feet in diameter, some idea of the magnitude of the work may be obtained.

The first step in the work was the dredging of a trench across the basin to the required depth and width with sloping sides. The concrete sections were then made in a drydock rented for the purpose. Huge steel forms were set up and the cylinders poured in three operations; first the lower section up to the floor line, then the floor slab itself, and finally the remaining two thirds of the cylindrical shell.

After the segment has been completely poured and set, the forms are removed, and a waterproof bulkhead is built across either end. This is made of heavy timbers covered with a tongue and grooved facing and then several layers of waterproof paper and asphalt. Steel rods are placed around the tube and drawn up tightly, so that the segments resemble sections of huge wood-stave pipe. Water is then admitted into the drydock and the tube is floated and towed a distance of about seven miles to the location of the tunnel.

When the segment is above its final position, seacocks are opened and it is slowly sunk into place and joined to the adjacent sections by a special concrete filler. In this way, the tunnel is built in drydock piece by piece and finally connected at the site of operations. The concrete which has been poured in the air has marked advantages over the product used underwater, and engineers are confident that this departure from orthodox methods will prove successful.



Copyright Eng. News Record

VEHICULAR TUNNEL UNDER ALAMEDA ESTUARY

Tube segment about to be towed out of drydock to the tunnel site and sunk into place.

The Smallest Electric Motor in practical use is made for a certain delicate type of demand meter. Its output is about one quarter of one millionth of a horsepower, and it stands but two inches high and weighs only four ounces. The rotor is a thin disk only one and ane-half inches in diameter. The entire motor throughout is a marvelous demonstration of precision in electrical manufacturing.

Effects of Florida Hurricane. A general study of the effects of the southern Florida hurricane of September 18 was recently undertaken by the Palm Beach Engineers' Association. A report on the damage to different types of buildings was submitted and in summary states that the major part of the damage was due to hurried and improper construction. It recommends as the best means of preventing similar damage in the future, the revision, enlargement and enforcement of building codes, with emphasis on enforcement. The value of competent design and supervision of building work was clearly demonstrated by the storm.

Noting that hardly any structural damage was done to tall buildings, except to two buildings of very narrow proportions in Miami, the report claims that the resistance of other buildings, although subjected to a terrific wind load in addition to impact, shows that buildings designed under standard building codes are adequate without special allowance, "except to provide as much bracing and stiffening as possible." Such damage as was done is found to be chargeable to faults and weaknesses in windows, doors, casements and curtain walls.

In smaller structures such as small apartments and office buildings, most of the damage can be attributed to the fact that many of them were hurriedly constructed without regard to proper precautions. Buildings carrying their loads on bearing walls appeared to suffer more than buildings having a natural skeleton.

A New Harmonic Balancer for counteracting and absorbing the tendency of an automobile crankshaft towards torsional vibration has been recently put on the market. The principle of an automatic balancer is best compared to a pedestrian's action in automatically and unconsciously swinging his arm in the direction opposite to that in which his leg is swinging. A small bar, pivoted at right angles to the crank shaft and with its ends held by tension springs, sets up a counteracting force in the crank shaft opposite and equal to the forces created by torsional vibration. The crank shaft, like the body of the pedestrian, thus is freed from vibration or sway. In the new device the flat leaf springs which support the ends of the usual harmonic balancer have been replaced by coil springs which balance the arm more effectively. These springs permit the use of a lighter and much more sensitive balancer arm thus causing a more efficient and quickly acting performance.

Largest Metal Propellers ever built have just been completed and are to be used on the new 5,000,000 cu. ft. capacity British Government airship R-101. These propellers weigh considerably less than if they were built of wood. They are of the detachable blade type and are adjustable as to pitch in the hub. The hub has a special reversing device so that the propeller can be used to check the speed of the ship when approaching the mooring mast for anchorage.

Here and There

Humorous notes from the Editor's desk

"MORE DEADLY THAN THE MALE"

The trite old saying that "A carpenter should stick to his bench" applies to journalism equally as well as to the manual occupation. We have often wondered what would be the result if one of our "sob sisters," those representatives of emancipated femininity in the realm of the press, should undertake a subject requiring knowledge of a field still remaining within the grasp of the retreating male. The comments of a "lady journalist" upon the electrical engineering development of her state in a daily newspaper seem admirably to demonstrate the awful consequences. To quote from the *Daily News* of Greensboro, N. C.:

"Through the use of hydro-electric power a wide channel of sanitation has been opened through the entire state. It would of course be impossible to even attempt estimating what this has meant to the health of the people. Hydro-electric power has brought not only industry and wealth but, of greater value, happiness and health.

"Great as has been the development of electric power in North Carolina we are yet a long way behind New England. There, electricity is used more universally for power, light and for transportation. Their colder climate gives them one great advantage. Theoretically the only limit of the work which the electric motor can perform is that which will melt the insulation around the wires; so the lower the temperature the more work the motor will do. With cheap power from the lakes and streams of northern New England one sees visions of electrically operated railroads which can defy the temperature and perform more work even in zero weather."

TASTES LIKE SHELLAC

It is a well known fact that shellac is used in making felt stiff. Of course more shellac must be used in derbies than in soft felt hats. An instructor in Industrial Chemistry in order to drive the point home, said that he had heard so much shellac was used in the manufacture of derbies that it would highly pay people to collect old ones and recover the shellac from them. It thrills us that there are so many ways for a young man to win a vast fortune. Pass the hat.

POUNDING IN THE FACTS

In *Time* we find proof of curiosity killing the cat again. Perhaps the cat was only wounded this time.

Members of the Danville, Ill., Rotary Club assembled recently to behold a marvel. Awe was in every heart as a man stood among them, all unafraid, and bade an assistant fire revolver bullets at him point blank. After the smoke had cleared away, the man still stood there unharmed, although the bullets had apparently hit their mark. But the investigators said they were not to be fooled and accordingly pushed forward for clearer observation. The man with the artillery was asked to blaze away again. The trick vest demonstrator remained unharmed as before, but this time three of the incredulous townsmen were knocked to the floor. A banker, a baker, and a newspaper reporter suffered cuts, scratches and contusions as chunks of lead spattered off the entertainer's fancy waistcoat—now proved bullet-proof beyond a shadow of a doubt—whirred among craning necks and peering heads, luckily injuring only three.

DARK

During the war the War Department of Great Britain was besieged with ideas for protecting London against air raids. One simple suggestion, of which to the best of our knowledge no use was ever made, came from a lady. She proposed to blind the Zeppelins so that they could not see their targets, by shining on them a powerful black ray.

AIRING NEW YORK'S REPUTATION

At a recent celebration of the Imperial Airways at Croydon airport, England, four new Handley-Page machines were christened by the wife of the air minister by pulling in each case a rip cord which revealed the name of the new plane painted on the fuselage. Names of the three "wet" planes (water-cooled) turned out to be the British colonial cities "Montreal," "Ottawa," and "Pretoria." The fourth plane was fitted with a "dry" (air-cooled) engine. A loud burst of laughter, showing that the crowd knew the irony of the conditions, came forth when the name "City of New York" was revealed.

MOTHER OF INVENTION

A young engineer was made late for his wedding by the breaking down of the train that was taking him to it. Wandering up to the front of the train, as the typical traveller cannot but help doing when he hears that something has gone wrong with the locomotive, he found the crew making a meagre attempt to repair a broken steam connection. Incensed because of his delayed wedding, he resolved that this cause should not be repeated. Accordingly he designed a new rounded thread on a specially reenforced pipe end that has now been adopted by all makers of railway equipment and other concerns that have use of a pipe joint as strong as the rest of the pipe.

EXPENSE IS NOTHING

A Tech man in the employ of a well known Cambridge firm of consulting engineers had occasion to make a series of boiler tests in a Massachusetts factory. The object of the tests was to demonstrate the improvement in economy obtained after certain changes had been made in the setting and other parts of the boiler installation.

The result was satisfactory, and with customary M.I.T. enthusiasm our young engineer, with sleeves rolled up and much of the boiler room soot still on his countenance, presented himself before the president of the manufacturing firm. "The change-over is a success. Before the change we evaporated only six lbs. of water per pound of coal. We now evaporate ten pounds of water per lb. of coal."

The President spoke sharply, "What! You are using more water! I won't have it. We have to pay for that water. It is metered."

BALMY OIL

The same firm of consulting engineers had made the customary tests on a sample of oil which a client requested them to "analyze." The client on receiving the report called up the laboratory chief and in a very modest manner stated that, while he was reluctant to question a report from a group of such high standing, he felt that in this case at least he must speak. This oil was a synthetic material. He had made it himself and he knew for a fact that there was no Baumé in it.

A sermon in stones

CECIL RHODES, the diamond king, had a real idea which he passed on to diamonds in the rough.

"Be well-rounded men, broad in your sympathies," he said, and he made this the basis for selection of Rhodes scholars.

Surely there's a lesson for every man—graduates alike in arts, in pure science or in applied science—to balance the student in him with the athlete, the individualist with the man of sociability, the specialist with the "citizen of the world."

For Rhodes' idea was no theory. It is shared by hard-headed business men today.

Published for the Communication Industry by

Western Electric Company

Makers of the Nation's Telephones

Number 64 of a Series

Recent Books

This department conducted in co-operation with the Technology Library

Magnetism and Atomic Structure. By Edmund C. Stoner. Lecturer in Physics at the University of Leeds, New York, E. P. Dutton and Company, 1926. 376 pages.

There is an immense amount of satisfaction in owning a copy of this new book which considers the fundamental significance of magnetism in relation to the theory of atomic and molecular structure and of radiation.

First of all, the eminence of the author is the greatest possible recommendation. Dr. Stoner in 1925 brought together all of the available data in physics with great ingenuity and made a great contribution to the new Bohr theory of atomic structure in assigning an electronic structure to every element from hydrogen to uranium, distributing all these electrons in orbits defined by three quantum numbers. This great piece of work has been widely accepted.

In the second place, Dr. Stoner attacks one of the most difficult of all subjects, and for the first time brings it into coherent and significant form. A survey of scientific abstract journals indicates at once the great interest now prevalent in the whole subject of magnetism, particularly from the standpoint of the quantum theory. Dr. Stoner shows that the basis of the quantum theory is still obscure and its formulation uncertain, and there are many gaps and difficulties in its development. Some of these become especially prominent in magnetism which was long regarded rather as a stumbling block for the quantum dynamical atomic theory. Closer consideration, however, shows that it actually yields remarkable strong support for it. It seems certain that the further study of magnetic phenomenon instead of undermining the quantum theory will greatly strengthen it as a coherent whole and will possibly throw light on its possible significance. For this reason magnetism has at present an immediate importance much wider than that arising from its own intrinsic interest. The method of the book is to give fairly complete outlines of representative researches and the basic discussions on these in the hope that a general and balanced account of the present state of the subject may be given. Beyond doubt this hope has been translated into achievement. The book makes available for the first time in English many of the great researches which have been too little known.

The author is to be complimented for driving fearlessly to the heart of the subject clearly and concisely without attempting to sugar-coat a subject which cannot be sugar-coated. Magnetism is scarcely a subject for popular reading and the lay reader of this book probably will not proceed far past the first chapter. The second chapter begins the discussion of the classical magnetic theory starting at once with equations in vector form simply because this is the only satisfactory way in which to appreciate the subject; in succeeding chapters are treated the experimental methods and survey of earlier results, the interpretation of magnetism as an atomic phenomenon, the quantum theory, para and ferro-magnetics, elementary moments and eccentric fields, gyro-magnetics, magnetic deviation of atomic rays, Zeman effect, other magneto-optical effects, diamagnatism effects, miscellaneous magnetic effects, magnetism and structure of the atom, magnetism in chemistry, and problems, summary and conclusion.

In conclusion it may be enthusiastically reaffirmed that this book for the first time makes magnetism in its great and growing importance really clear. It is the last word upon the subject and a whole library of widely scattered and unrelated literature in itself. Science is deeply indebted to Dr. Stoner for this great service.

G. L. Clark

Practical Colloid Chemistry. By Wolfgang Ostwald, Professor of the University of Liepzig. With the collaboration of Dr. P. Wolski and Dr. A. Kuhn. Translated from the Fourth German Edition by I. Newton Kugelmass, M. D., Ph. D., Sc. D., Yale University School of Medicine and Theodore K. Cleveland, Ph. D. Published by E. P. Dutton and Company, New York. Illustrated 1924. 191 pp.

This book is an elementary experimental development of colloidal chemistry intended for use as a laboratory manual. It is written very clearly and concisely which makes it invaluable to the student who dislikes to wade through long discussions of colloid phenomena in order to get the fundamental principles.

There are ten chapters systematically arranged which include the Preparation of Colloidal Solutions; Diffusion, Dialysis, Ultrafiltration; Surface Tension and Viscosity; Optical Properties; Electrical Properties; Experiments with Gels; Adsorption; Coagulation; Peptization and Related Phenomena; Commercial Colloids and Other Material for Demonstration Experiments; and Dispersed Analysis.

Each chapter begins with a brief thorough explanation of the subject to be studied followed by numerous experiments which fully explain the phenomena. The procedure for carrying out the experiments both as to apparatus and method is simple, definite and readily understood. There are several diagrams, curves and illustrations which bring out clearly the fundamental principles of colloidal phenomena.

Although this book has not the discussions on colloidal chemistry which are necessary in a lengthy text on the subject, its many laboratory experiments cover the subject so well that a perusal of it will make one fairly well acquainted with colloid chemistry. It will also prove to be of valuable assistance in a laboratory dealing with this branch of chemistry.

E. H. Damon

Physics for Colleges. By H. Horton Sheldon, Ph. D., Associate Professor and Chairman of the Department of Physics, Washington Square College, New York University; C. V. Kent, Ph. D., Associate Professor of Physics, University of Kansas; Carl W. Miller, Ph. D., Assistant Professor of Physics, Brown University, and Robert F. Paton, Ph. D., Associate Professor of Physics, University of Illinois, New York; D. Van Nostrand Company, 1926, 655 pages.

A new book on an old subject but not just another book on physics. One has only to glance through the pages to realize that this book is different. This is mainly accomplished by treating each section entirely from the point of view of modern physics rather than giving the modern view as a sort of appendage.

The book has four authors, each author treating in his own way that section for which he was particularly fitted. The section on "Mechanics" was written by Professor Miller, "Heat and Molecular Physics" by Professor Sheldon, "Electricity and Magnetism" by Professor Paton; and "Sound and Light" by Professor Kent.

In general as each new subject is taken up a short historical outline of the development of various theories on the subject is first given. This is followed by a few simple statements of the modern point of view on the subject. A few fundamental formulas are then deduced by a little elementary reasoning, a few resulting formulas are given, an example or two, then ten or twelve problems.

The book is not very technical or mathematical and it is probably better adapted for courses in General Physics than for use in Engineering Schools. No attempt is made to give the mathematical proof or derivation of the formulas used. There are several very interesting chapters on subjects that are usually barely touched upon or entirely omitted from the usual book on Physics. For example there are chapters on Planetary Motion, Meteorology and Radiation.

The material in the book is well covered by groups of problems and questions at the end of each section.

The problems are all straightforward and in most cases require only the substitution of the data given in one of the formulas given in the discussion. The answers are given with each problem but as is usual with problem answers they are not absolutely reliable. This may be a result of poor proof reading.

The book is a very worthwhile contribution to its field and the authors are to be commended on treating the subject from such a modern point of view.

N. Olmstead

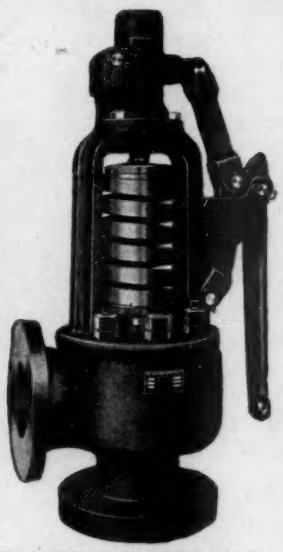
Investigations on the Theory of the Brownian Movement, by Albert Einstein. Edited with Notes by R. Fürth, translated by A. D. Cowper. With 3 diagrams. New York, E. P. Dutton & Company. VIII + 124 pages; $1.75.

To the lay mind Einstein is best known by his celebrated theory of relativity, a theory marked by conceptions so bold, yet so natural, by conclusions so contrary to age-old acquired notions that even today, after ten years of minute examination, it stands out as one of the most widely discussed of contemporary scientific achievements. That Einstein has left his everlasting imprint on almost every one of this century's big advances in physics, a century replete with epochal developments, is not so well known outside of the specialist's narrow circle.

In this little volume Fürth has collected Einstein's fundamental papers on the theory of the Brownian movement—the perpetual haphazard motion of microscopically visible particles suspended in a fluid—and supplemented them with elucidating notes at appropriate places. The first paper, published in 1905, is concerned with the proof that, according to the theory that heat is a mode of motion of the molecules, "bodies of microscopically visible size suspended in a liquid will perform movements of such magnitudes that they can be easily observed in a microscope." No attempt is made as yet to correlate these movements with Brownian movements, chiefly on account of the then meager experimental data. In the second paper, published a year later, the results of the first paper are extended to include rotational motions. Here Einstein is confronted with the deficiency in the physical hypothesis

(Continued on page 350)

Consolidated Safety Valves and Hancock Valves are now in actual service at a working pressure of 1390 pounds



FORMS DSA-DSB-DSC—Consolidated Safety Valves with steel body.

CONSOLIDATED POP SAFETY VALVES

are made for service on all types of stationary boilers, marine boilers, locomotive boilers, portable boilers, house heating boilers, pressure tanks and pipe lines and for oil, oil vapor or water relief. Made in cast bronze, cast iron, and cast steel. All conform to A.S.M.E. code.

FORM DI—saturated steam up to 250 lb.

FORM DS—RB—saturated steam up to 400 lb. superheated steam up to 300 lb.

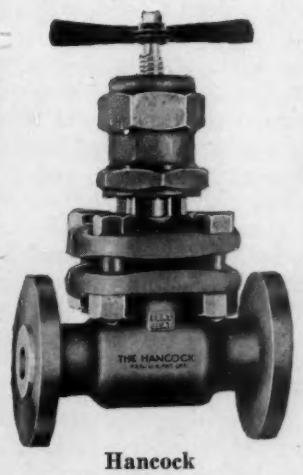
FORM DSA—saturated steam 400 to 500 lb. superheated steam 301 to 450 lb.

FORM DSB—saturated steam 500 to 700 lb. superheated steam 450 to 700.

FORM DSC—saturated steam 700 to 1500 lb. superheated steam 700 to 1500 lb. 800 deg. F. Temp.

FORM LU—for Economizer Service all pressures.

FORM LU — Consolidated Water Relief Valve for Economizer Service.



Hancock Forged Steel Valve

HANCOCK FORGED STEEL VALVES
Sizes ½ to 2 in. inclusive.
All pressures to 1200 lb.
Total temperature 1000 deg. F.

HANCOCK VALVES

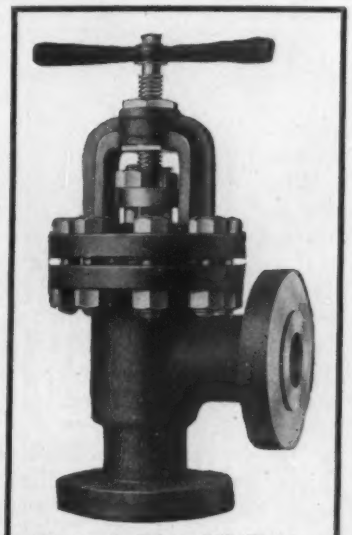
will give you dependable tight service under high pressure and severe operating conditions. Can be furnished with flat or bevel seats and disks, or for throttling service with cone type seat and disk.

HANCOCK BRONZE VALVES
Saturated steam to 300 lb.
Superheated steam to 200 lb.
Total temperature 500 deg. F.

HANCOCK CAST STEEL VALVES
Screw bonnet type to 400 lb.
Flanged bonnet type to 600 lb.
Total temperature 900 deg. F.

ASHCROFT GAUGES
Indicating Gauges in sizes up to 12 in. for all pressures

METROPOLITAN INJECTORS
Single Tube and Double Tube



Hancock Blow-Off Valve

HANCOCK BLOW-OFF VALVES
are designed for extra heavy duty. Pressures range from 250 to 1500 lb.

MAXWELL MANNING & MOORE INC. M&M TRADE MARK

Shaw Electric Cranes
Putnam Machine Tools
Ashcroft Gauges
Hancock Inspirators and Valves
Consolidated Safety Valves
Metropolitan Injectors

MANNING, MAXWELL & MOORE, INC.

100 East 42nd St., New York, N. Y.

29 North Jefferson St., Chicago, Ill.

BRIDGEPORT WORKS
Ashcroft Gauges
Consolidated Safety Valves
Bridgeport, Conn.

BOSTON WORKS
Hancock Valves
Metropolitan Injectors
Boston, Mass.

The Technical Graduate and Transportation

(Continued from page 311)

inum alloy, cheaper, lighter and better than steel." Scientists and engineers know that such a metal can be produced, but to make it economically such water power facilities as exist at Muscle Shoals are needed.

I am not sure but that the acquisition of Muscle Shoals by Ford will mark the introduction of a new low priced metal which would revolutionize the automobile and railroad business from the standpoint of cost of materials used, and thereby usher in a new era of industrial prosperity for America.

With aluminum now at 27c a pound and the price of bar steel 3c, imagine the saving that could be made in the weight and economics of automobiles, railroad cars, steel rails, buildings and all materials of construction, if a new and better metal could be produced to sell near the price of steel.

Five things brought about the present great industrial era. These five things include:—

1. Steam as a prime mover in transportation.
2. The Bessemer process of making cheap steel in volume.
3. The McCormick reaper to replace hand power on the farm.
4. The internal combustion motor which made the automobile possible.
5. The development of a nation wide system of communication by telegraph, telephone and radio.

What we need more than anything else right now is more work and less conversation.

If I told you what I thought about the future, about what is likely to happen in the next twenty-five years from the standpoint of business, you would think I was crazy. The trouble is that it is so confounded easy to make a living in this country that most of us are dreaming of what a wonderful thing it would be if we didn't have to work at all. The man whose father used to shine his shoes with a dash of cold water and a little stove polish, is ashamed to give the waiter in the dining room less than fifty cents for a tip, and there are a lot of people sitting around drinking Scotch whiskey at $12.00 a bottle and talking about the impending business depression. The fact of the matter is that business gets better and better with the man who really works. It has its temporary ups and downs, but on the long pull this is the greatest country on the face of the earth and we are living in the greatest period since the world began.

However, while transportation and communication are going ahead at a rapid rate, the business of agriculture is still lagging behind. The politicians have been trying to convince the farmers of the middle west that what they need is legislation. Ford knows that what they need is more modern implements, and what the farmers of the northwest need more than anything else is to get out of politics and go back to farming.

Not long ago the United States government appointed a commission for the relief of the Balkans. Everybody knows that the corn belt extends around the world along the 40th parallel. Everybody wondered why Servia could not produce corn like Illinois and Iowa. The commission spent a quarter of a million for machinery and seed, and in one season turned Servia from a starving nation into a nation producing enough food for home consumption with thousands of train loads for export. It only required brains, imagination, soil, seed and sun.

Some people erroneously believe that the tractor business has struck a snag and that it will not solve the problem of the farmer. That is what they thought about the automobile about 1905.

You know Ford said the trouble with the farmer is that he would rather carry water one hundred yards in a pail than put in a pump and pipe it to the barn.

Not many years ago one of the men in the United States Patent Office decided that he would resign. He thought the patent office might well be discontinued as everything worth while had already been patented.

Listen while I briefly tell you some things that have happened and some that may happen in the future.

Truly, it is a great thing to be crazy —just as crazy as Ford—as insane as Edison—as mad as Steinmetz—as wild as DeForrest—and as daffy as Kettering. Think how crazy Goodyear was to be monkeying around with a combination of crude rubber and sulphur, and think how clumsy he must have been when he accidentally dropped some of it on a hot stove and discovered the secret of vulcanizing.

Think how foolish was that man who decided that the old carbon filament used in the incandescent lamp was too brittle. He conceived of the new tungsten filament which is three times more efficient. Just imagine a bar of tungsten fourteen inches long with a quarter inch cross section, drawn into a thread twenty-five miles long and one sixth the size of a human hair.

Consider the nerve of the man who conceived that he could produce in a few days a substance which it took nature one thousand years to make—and that is carborundum.

Imagine the possibilities in the heat treatment of metals.

Within the last few years the production of the drop forged aluminum connecting rod has made possible a reduction of fifty per cent in weight with an improvement in quality.

Young John Hays Hammond demonstrated that ships at sea could be controlled by radio from land, and wouldn't you be astounded if within the coming generation you witnessed the spectacle of a man going to his business in an aeroplane and sending the machine back home to the hangar by radio.

Did you ever try to imagine what George Washington would say if he saw the Twentieth Century Limited flying down the Hudson River valley, with aeroplanes darting overhead? What would he think if a man picked up a telephone and started to talk to Los Angeles? Imagine his sensations listening to President Coolidge on the radio, or the voice of Caruso, now dead, on the Victrola.

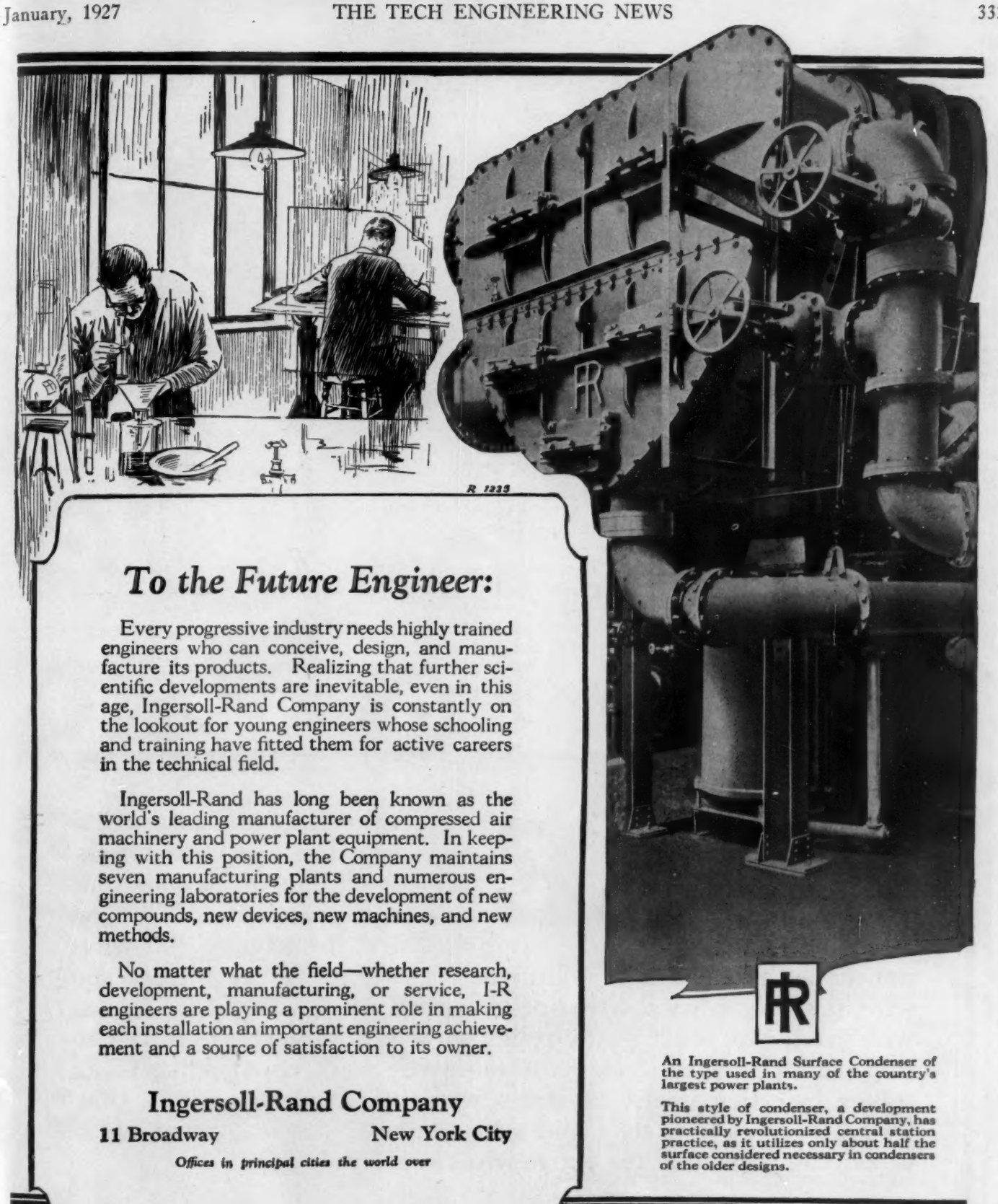
When the Declaration of Independence was signed the world was moving by horse power and sailing vessels, lighted by whale oil lamps, and the farmer worked with a hoe and scythe. We had no steamships, no movies, no daily news, no telegraph, no anesthetics, no electricity, no fuel oil, no wireless, no Victrolas, no automobiles and yet people are always talking about the good old days.

Consider the development of individual transportation as compared with group transportation provided by the railroads before the advent of the automobile.

The internal combustion motor developed by Gottlieb Daimler—the high tension magneto developed by Robert Bosch—the commercialized starting and lighting system developed by Charles Kettering—and the float carburetor—made this great instrument of individual transportation possible.

The population of the earth has doubled in the last ninety years. Today it is estimated at one billion, seven hundred and forty seven million. The increase in population in the

(Continued on page 338)



To the Future Engineer:

Every progressive industry needs highly trained engineers who can conceive, design, and manufacture its products. Realizing that further scientific developments are inevitable, even in this age, Ingersoll-Rand Company is constantly on the lookout for young engineers whose schooling and training have fitted them for active careers in the technical field.

Ingersoll-Rand has long been known as the world's leading manufacturer of compressed air machinery and power plant equipment. In keeping with this position, the Company maintains seven manufacturing plants and numerous engineering laboratories for the development of new compounds, new devices, new machines, and new methods.

No matter what the field—whether research, development, manufacturing, or service, I-R engineers are playing a prominent role in making each installation an important engineering achievement and a source of satisfaction to its owner.

Ingersoll-Rand Company

11 Broadway New York City

Offices in principal cities the world over

An Ingersoll-Rand Surface Condenser of the type used in many of the country's largest power plants.

This style of condenser, a development pioneered by Ingersoll-Rand Company, has practically revolutionized central station practice, as it utilizes only about half the surface considered necessary in condensers of the older designs.

Ingersoll-Rand

Welding All-Steel Automobile Bodies

(Continued from page 320)

produce a satisfactory surface. This condition of low spots in sheet metal is a very serious item, and much depends upon the method of handling the pieces while welding as to whether or not you can produce the so-called low spots in such a manner as to have only a minimum amount of finishing.

In some cases, where spot welds are made on radii, it is possible to spot weld metal sheets together in such a manner as to cause part of the metal at the weld to project or protrude above the surface of the surrounding metal by forming a small teat or projection at the weld. The weld is so made that this projection protrudes from the surface to be finished—that is the surface in which any low spots would be objectionable as stated heretofore. After the metal sheets have been joined together by a series of welds made in this manner the small teats or projections are removed in any suitable manner—as, for instance, by grinding them down to the level of the surrounding surfaces. This new surface then has no low spots, and its appearance when finished, will be very desirable.

The lower electrode is of the form commonly used on all makes of electric welding machines and the upper electrodes are of the usual form except that they have a small conical recess arranged centrally in the lower end of electrode. The metal sheets are inserted between the electrode having the recess. The electrodes are caused to approach each other and engage and clamp between the overlapped metal sheets, the electrical circuit being so closed that the current flows from one electrode to the other through the metal sheets. The heat generated by the passage of the electric current through the metal sheets, at the point where they are engaged by the electrodes, causes the metal to fuse and, since the electrodes apply considerable pressure at this point, the fused metal is also forced into the recess of the electrode forming the small projection at the weld, which protrudes from the surface to be finished. A "low" spot will also be formed at the weld in the exposed surface of the sheet, but this is not objectionable since this surface is not to be finished. When the sheets are connected by the usual spot welding operation, such low spots are formed in both of the exposed surfaces and it is to be noted that with this process of spot welding, these low spots are eliminated.

The second step in this process consists in the removal of these weld projections. This is done very satisfactorily by grinding or filing them down to the level of the surrounding surface. The result is that the exposed surface of the metal sheet is uniform and without any objectionable depressions. In using this method in actual practice, the metal sheets which are joined together have been of steel and the electrodes which are used have been of copper.

It is to be noted that, by the use of this process in cases where one of the surfaces of these welded members is to be finished, the work can be accomplished at a lower cost than heretofore. The welding operation is no more costly and no slower than heretofore and the amount of grinding necessary is much less than has been required, previously. It is a much simpler and cheaper operation to grind

(Continued on page 336)

WIRE automobile and airplane wires, electrical wires, submarine cables, bridge-building cables, wire rope, telegraph and telephone wire, radio wire, round wire, flat wire, star-shaped and all different kinds of shapes of wire, sheet wire, piano wire, pipe organ wire, wire hoops, barbed wire, woven wire fences, wire gates, wire fence posts, trolley wire and rail bonds, poultry netting, wire springs, concrete reinforcing wire mesh, nails, staples, tacks, spikes, bale ties, steel wire strips, wire-rope aerial tramways. Illustrated story of how steel and wire is made, also illustrated books describing uses of all the above wires sent free.

AMERICAN STEEL & WIRE COMPANY

Sales Offices

Chicago New York Boston Cleveland Worcester Philadelphia Pittsburgh Buffalo Detroit Cincinnati Baltimore Wilkes-Barre St. Louis Kansas City St. Paul Oklahoma City Birmingham Memphis Dallas Atlanta Denver Salt Lake City

Export Representative: U. S. Steel Products Co., New York

Pacific Coast Representative: U. S. Steel Products Company, San Francisco, Los Angeles, Portland, Seattle

WRIGLEY BUILDING · *Chicago*
Graham, Anderson, Probst & White, *Architects*
Lanquist & Illslev Company, *Contractors*

MISSISSIPPI WIRE GLASS CO.
220 Fifth Avenue
Chicago New York *St. Louis*

Judge a Cutter by its Chips

THE worth of a cutter is measured by its chips, and the costs in the milling department of any plant are measured by the "cut ability" of the cutters.

Here is a Brown & Sharpe Staggered Tooth Side Milling Cutter taking a cut 1⅛" wide and 2" deep in steel, and the chips tell a story of clean-cutting performance. But the picture cannot show you the long record of steady service Brown & Sharpe Cutters make on such production work, when every moment gained or lost shows up on the cost sheet.

In the constantly increasing number of plants where "rock bottom milling costs" is the watchword, you'll find much of the cutter equipment stamped Brown & Sharpe.

There is considerable information about cutters in the No. 30 Small Tool Catalog. We will gladly send a copy at your request.

BROWN & SHARPE MFG. CO.
PROVIDENCE, R. I., U. S. A.

Welding All-Steel Automobile Bodies

(Continued from page 334)

the weld projections down to the level of the surrounding surface, than to grind the surface down to the level of the "low" spots, at the welds.

Strength Of Spot Welds

The question is frequently asked, how do spot welds and riveted joints compare in strength. It is not my intention to go fully into this question here, but I may say briefly that there is no substantial difference in our use of them. If two thin pieces of metal and two thick pieces of metal be riveted with rivets of the same size there is a certain thickness of metal below which all failures will arise through the tearing of the sheet and above which failures will be due to the shearing of the rivet. The same is true of spot welds if the area of the spot weld be held constant. The table below gives test results on spot welds applied to sheets of different thickness, but the area of the weld itself is nearly constant. In the examples given when the thickness of the metal is above .062 inch, the weld itself undergoes shear. Had the area of the weld been greater, the weld would have failed in shear only with a greater thickness of metal. Exactly the same thing happens with rivets. When the section of the rivet is small and that of the sheet large, it is always the rivet which fails.

Tensile Tests Of Spot Welds In Sheet Metal

Metal Thickness	Area of Weld	Load lbs.	Shear stress on weld per sq. in.
			Sheet broke around weld
Steel—.031	.048 sq. in.	800	16700
" —.043	.055 sq. in.	1470	26800
" —.050	.051 sq. in.	1230	24300
" —.062	.054 sq. in.	2140	39600
			Broke through weld
" —.078	.049 sq. in.	2210	45000
" —.088	.0594 sq. in.	2820	47400

Tensile Tests Of Rivets In Sheet Metal

Single Rivets

These rivets were headed by machines as used in the shop. The backing up tool was a diamond knurled flat surface. Force was applied to the head of the rivet by an air hammer fitted with a die made to suit mushroom head of rivet. The diameter of the rivets was .25".

Metal Thickness	Load lbs.	Shear stress on Rivet—lbs. per sq. in.
		Rivet pulled out of strip
Steel—.025	840	17100
" —.039	945	19300
" —.048	1500	30600
" —.059	1395	28400
" —.070	2010	41000
		Rivet sheared off
" —.088	2175	44300

Two Rivets

Metal Thickness	Load lbs.	Shear stress on Rivet—lbs. per sq. in.
		Metal strip broke
Steel—.039	1355	13800
" —.057	2460	25300
" —.088	4265	47400

Single Rivets

Rivets used were 3/16" diameter and were mushroom headed both sides. Riveting done with air hammer.

Metal Thickness	Load lbs.	Shear stress on Rivet—lbs. per sq. in.
		Rivet pulled out of strip
Steel—.031	705	25300
" —.043	945	34400
" —.050	1110	40200

(Continued on page 338)

The Tech Engineering News

is the Professional Journal of the Undergraduates at the Massachusetts Institute of Technology.

is published monthly, October to May, and contains Articles of general Scientific and Engineering Interest besides many of Institute Activities.

is desirous of having You upon its Mailing-List. Subscription Price is $1.50, but check does not need to accompany order. Use this Coupon.

*Name*_____

*Address*_____

_____

Electrical Equipment

LESS THAN WHOLESALE

High Frequency Buzzer, Telegraph keys, Quartz Crystals, Globe Hand Microphone, Federal Phones, RCA Power Transformers, RCA Magnetic Modulators UP-1367, 3½-5 Amps. "Q" Rectifying Tubes. Teco Plug-in Coils, Oscillating Trans. UL-1008, Power Rheostat, Commercial type Helix, RCA TF Transmitter, Photo-Electric Cell (circular on request), Kennedy Taper plate three gang condenser, Short Wave Receivers and Transmitters, Magnavox Power Amplifier Model AC3C 3 stage.

We sell Tech students at our regular wholesale prices. This equipment is suitable for:

Radio, X-Ray

Thesis and Experimental

Work

See Bill Horlick M. I. T. '22

RADIO SURPLUS CORP.

250 WASHINGTON ST.

BOSTON, MASS.

PROTECTION!

A 25,000-ampere, 250-volt D. C. I-T-E type LG motor operated Circuit Breaker.

Consulting and operating engineers refuse to specify other than I-T-E on important installations.

And, indeed, why should this not be the case? Has not Cutter led the field for forty years and are there not *thousands* of installations, both large and small, all over the country giving superlative satisfaction to prove they are worthy of being called leaders?

When we put an I-T-E Circuit Breaker on the market its satisfactory performance is assured.

There is no guess-work about it. The experimentation is all done, where it should be done, in the laboratory and shops of the manufacturer—not in the plants of our customers.

THE CUTTER COMPANY
ESTABLISHED 1888—PHILADELPHIA

When writing to advertisers please mention the Tech Engineering News

CUTTER

U-RE-LITE I-T-E CIRCUIT BREAKERS

15

Welding Automobile Bodies

(Continued from page 336)

		Rivet sheared off
" —.062	1490	53900
" —.078	1610	58200
" —.088	1325	47800

Two Rivets

Same diameter rivets used—same type head.

Metal Thickness	Load lbs.	Shear stress on Rivet—lbs. per sq. in.
Steel—.062	1770	*12850
" —.088	2945	*21300

*Metal torn and rivets pulled out at side of holes.

Although all automobile manufacturers at present are not using welded All-Steel Bodies neither do all of our railroads at present use All-Steel Coaches and Pullman Cars, yet the All-Steel Automobile body holds the same position from a safety standpoint, with relation to the wooden frame composite body, as the All-Steel Coach and Pullman cars hold to the wooden cars.

Our recollections of railroad disasters picture to us the results very clearly from the use of steel or wooden cars. The wooden cars crush, break apart, and usually burn with a resultant deplorable loss of life, whereas the steel coaches retain their form, and, although, perhaps somewhat distorted, they do not break apart, and the occupants, therefore, are afforded the maximum of protection.

Welded all-steel automobile bodies have been known to roll down mountain sides and turn over and stand on their roofs without damage to the structure of the body.

The time is not far distant when the automobile buying public will demand the safety and protection of welded all-steel automobile bodies and from year to year we shall see more automobile manufacturers using this modern development in automobile body structural design to keep pace with the rapid advance of civilization.

HELIUM AND HYDROGEN. One of the dreams of the alchemists seems to be in the course of fulfillment by modern physicists. Recently word has come from Berlin that two professors in the university there have succeeded in converting hydrogen into helium. This was done by passing a current of hydrogen over sponge Palladium for several hours. The amount of helium obtained was so small it could be detected only with the spectroscope, but later experiments may produce larger quantities.

Transportation

(Continued from page 332)

United States over deaths and departures, has averaged nearly four thousand persons each day. The population of the United States has been doubling every thirty years during the last century. If this rate increases we will have seven hundred million people in less than one hundred years. The statisticians at Johns Hopkins say the population of New York will be twelve million in 1933. The greatest danger facing the earth today is that of over population.

Science alone promises salvation.

This means that New York and all other large cities, must eventually become cities of subways, with super imposed truckage ways, and above these passenger vehicle ways, and on top of all broad passage ways for millions of pedestrians.

Arrhenius, the famous Swedish scientist, has listed the sources of energy possible of future scientific development. They include solar radiation, air currents, evaporation, flowing water, storage plants, coal and oil. He says the total water power of the world is 745 million horse power.

Herbert Hoover says that super power will save thirty million tons of coal a year.

Centralized distribution of light and heat has already been achieved.

The ice man, the gas man and the milk man will disappear.

In their places will be super organizations for the distribution of heat and refrigeration.

The super automobile of the future will sell for a small sum. Practically every man, woman and child may have one.

There is only one thing I regret and that is that I cannot live for another hundred years—the progress of the world is so intensely dramatic and the possibilities of the next generation so tremendous.

Selected Grades

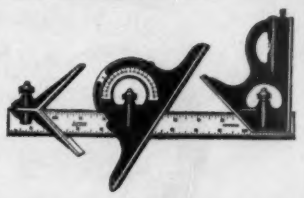
Anthracite

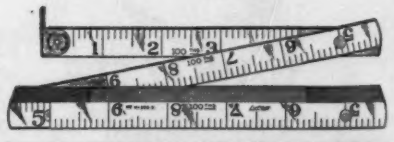
and

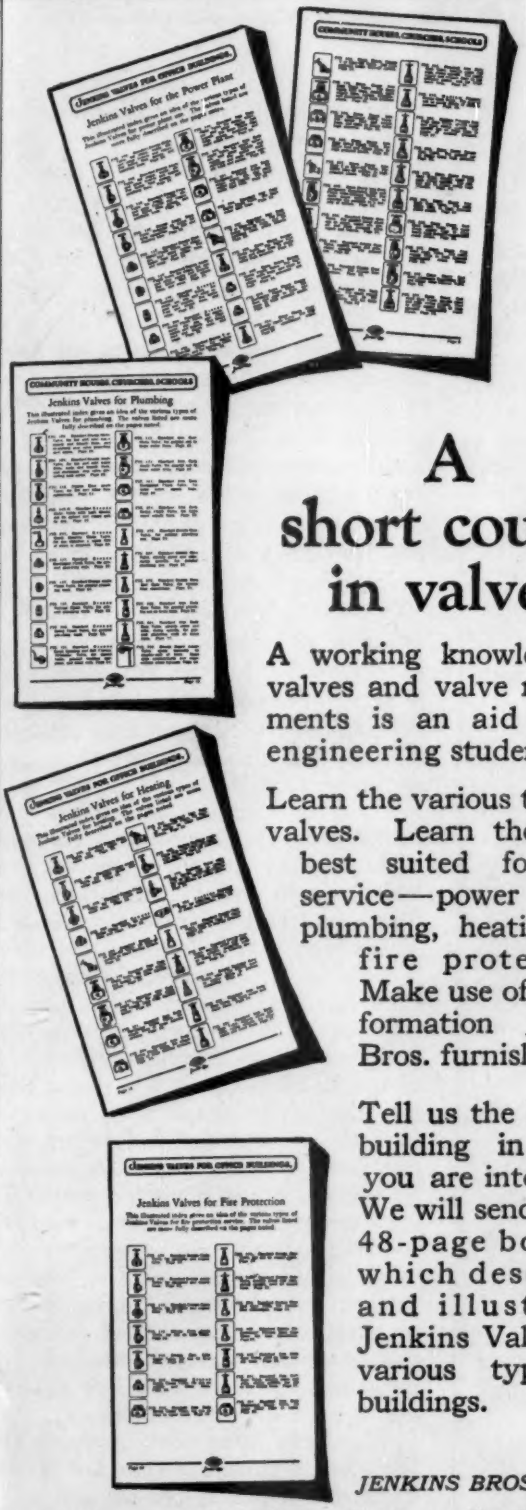
Bituminous

COAL

BURTON-FURBER
COAL COMPANY
50 CONGRESS STREET
BOSTON


LUFKIN
TAPES
RULES
LUFKIN
SMALL
TOOLS
DISTINCTIVE IN QUALITY
Made in patterns best suited to every class of work
SEND FOR
Cat. No. 11—Tapes and Rules Cat. No. 5—Tools
THE LUFKIN RULE CO. SAGINAW, MICHIGAN
NEW YORK WINDSOR, CAN.




Jenkins Valves for the Power Plant
Jenkins Valves for Plumbing
Jenkins Valves for Heating
Jenkins Valves for Fire Protection

A short course in valves

A working knowledge of valves and valve requirements is an aid to the engineering student.

Learn the various types of valves. Learn the types best suited for each service—power plant, plumbing, heating and fire protection. Make use of the information Jenkins Bros. furnish.

Tell us the kind of building in which you are interested. We will send you a 48-page booklet which describes and illustrates Jenkins Valves for various types of buildings.

JENKINS BROS.

80 White Street.....New York, N. Y.
524 Atlantic Avenue.....Boston, Mass.
133 No. Seventh Street, Philadelphia, Pa.
646 Washington Boulevard, Chicago, Ill.

JENKINS BROS., LIMITED
Montreal, Canada London, England

The above are valve index pages from Jenkins Booklets

Always marked with the "Diamond"
Jenkins Valves
SINCE 1864

KEYSTONE COPPER STEEL

Steel Sheets that Resist Rust!

The destructive enemy of sheet metal is *rust.* It is successfully combated by the use of protective coatings, or by scientific alloying to resist corrosion. Well made steel alloyed with Copper gives maximum endurance. Insist upon

KEYSTONE
Rust-Resisting Copper Steel
Sheets

Black and Galvanized

Keystone Copper Steel gives superior service for roofing, siding, gutters, spouting, culverts, flumes, tanks, and all uses to which sheet metal is adapted—above or below the ground. Our booklet *Facts* tells you why. We manufacture American Bessemer, American Open Hearth, and Keystone Copper Steel Sheets and Tin Plates.

Black Sheets for all purposes
Keystone Copper Steel Sheets
Apollo Best Bloom Galvanized Sheets
Apollo-Keystone Galvanized Sheets
Culvert, Flume, and Tank Stock
Corrugated Sheets
Formed Roofing and Siding Products
Automobile Sheets—all grades
Electrical Sheets, Special Sheets
Deep Drawing and Stamping Stock
Tin and Terne Plates, Black Plate, Etc.

Our Sheet and Tin Mill Products represent the highest standards of quality, and are particularly suited to the requirements of the mining, engineering, and general construction fields. Sold by leading metal merchants. Write nearest District Office.

American Sheet and Tin Plate Company
General Offices: Frick Building, Pittsburgh, Pa.
DISTRICT SALES OFFICES
Chicago Cincinnati Denver Detroit New Orleans New York Philadelphia Pittsburgh St. Louis
Pacific Coast Representatives: UNITED STATES STEEL PRODUCTS CO., San Francisco Los Angeles Portland Seattle
Export Representatives: UNITED STATES STEEL PRODUCTS CO., New York City

Modern Fireworks

(Continued from page 313)

cise great care in mixing any of these color formulae in any but very small quantities. At first the sample should always be tested for friction and shock as impurities present in any of the ingredients may cause the mass to be unduly sensitive.

BOMBSHELLS

A bombshell of the type ordinarily used in the fireworks business is made entirely of paper wrapped with string and made rigid with paste and animal glue. The time fuses are made of strong fibre paper and loaded with black powder, known to the trade as meal powder, which is pounded into them quite hard in the dry state.

This operation is always done by an expert since the lives or limbs of those in the audience as well as the man who fires the shell depend upon the perfection of the fuse and the care with which it is firmly attached to the bombshell so as to withstand the shock of the driving or ascending charge. The fuse in a bombshell is ignited at the same instant that the ascending charge is set off under the shell at the bottom of the mortar.

The fuse and quick match that ignites the propellant charge as well as the propellant or blowing charge itself; is of gunpowder because it is dependable. The bursting charge, also of gunpowder for the same reason, throws out and ignites the varicolored stars. The fuse is timed so as to agree with the ascending time of the bombshell, which is usually about three seconds (depending upon the weight of the shell and the amount of propellant or blowing powder used). The usual height at which a bombshell is exploded is from 500 to 600 feet from the earth. This depends, of course, largely upon the time required for the particular type of star to be consumed after it has left the exploded shell; this time must be less than that required for these particular stars to descend.

Many of the best effects are produced by using large comet stars made with recesses in their centers into which small reports are placed and fused so that when the bombshell bursts high in the air these comets are thrown in all directions, each comet exploding and blowing thousands of fragments of the comet about, each fragment in turn leaving a trail of golden sparks behind as it files through the air; the whole timed to a nicety so that all is consumed before reaching the earth. There was also designed by the writer for the same purpose, a very fine exhibit of batteries of silver —streamer stars.

These were made to fire from the ground several hundred shooting stars or silvery fern leaf shaped streamers that extended several hundred feet into the air making a wall of solid silver sparks of great brilliancy.

Wonderful effects are obtained with the giant bombshells that are thrown hundreds of feet in the air and which upon bursting release clusters of smaller bombs, each in turn bursting forth in all the colors of the rainbow, while others release squirming hissing serpents of fire that rush through the air leaving a fiery trail behind them.

SET PIECES

The use of colors in fireworks is not confined to stars ignited in mid air but is also used in making picture set pieces. For instance, the American flag is made in fire by combining the

(Continued on page 344)

Sheet Metal Stampings

TELEPHONE DIRECTORY STAND
with
REVOLVING SHEET METAL CABINET
Used in Telephone Exchanges

PETER GRAY & SONS, Inc.

Manufacturers of Sheet Metal Specialties since 1878

Third and Binney Streets - East Cambridge, Mass.

INSULATION PROBLEMS

are properly solved only by:

First: Selecting the right type of high grade insulation to meet the special engineering conditions.

Second: Determining the proper thickness for maximum efficiency.

Third: Seeing that insulation is thoroughly applied.

Fourth: Selecting the proper protection against atmospheric conditions, external injury, etc., and by sealing the insulation.

We meet these requirements with:

First: 85% Magnesia, high temperature insulation, hair felt, and cork, or a combination of two or more of these materials.

Second: Care in balancing amount of insulation against cost and efficiency.

Third: Employing experts in all branches of the art.

Fourth: The use of Thorkote—the ideal seal and protection.

Specifications and information furnished on request

P. S. THORSEN & CO., INC.,
81 Coffey Street,
BROOKLYN, N. Y.
Tel. Henry 3081-2

P. S. THORSEN CO. OF MASS.,
43½ "L" Street,
SO. BOSTON, MASS.
Tel. So. Boston 1330

Purdue's Personnel System

(Continued from page 321)

tunity to show the caliber of work which the graduate will do, a progress blank (personality rating blank) is sent to the employers of the graduates. On the blank the employer reports the progress which the graduate is making with his company. If the report from the employer is unsatisfactory, the fact is communicated to the alumnus together with suggestions about overcoming the deficiencies mentioned by his employer. Letters are sent to the employer asking his cooperation in giving the graduate the best possible opportunity and encouragement to improve.

An evidence of the approval that the industries have given is the fact that the initial funds were donated by the Indiana Manufacturers' Association, as is also a substantial portion of the current expenditures. Hundreds of complimentary letters have been received from the industries and from students and graduates who have been helped by the system. Another proof of the usefulness of the system is that our graduates are making good in engineering, and more and more companies are coming each year to employ Purdue seniors.

If the engineer's personality is bettered, if he is guided properly vocationally, if he is started in his life work with all the encouragement and the opportunity possible, we feel that the young Purdue engineer will be benefited throughout his whole life, and that the accomplishments of the system will more than repay for the expenditures of time and money involved in its operation.

Editor's note:

We are awaiting with interest the other articles of the series which the Purdue Engineering Review has promised to publish. Those which are to follow will take up the interesting proposition of what happens to the graduate who accepts an engineering job. The author speaks with authority, for he spent the summer of 1926 in a number of large plants on the job with recent Purdue graduates, usually unknown to them.

Conf. Rec. No.

Purdue University Student's Personnel Record

Entered ____ 19__ Graduated ____ 19__
Left ____ 19__ (?) ____ 19__

Name (In full) ____ (Last) ____ (First) ____ (Middle) ____ Class 19__ Course ____ Major Subject ____
Date and place of birth ____ 19__, ____ Nationality ____ Color ____ Nickname ____
Parent or Guardian ____ Permanent Address ____
Parents Occupation ____ Nationality of Parents ____ Parents Education ____ B. ____ S ____
Practical Experience before entering Purdue ____
Name and address of High School ____ What Scholastic third of H. S. Class ____
Practical Experience during vacations, 1st ____
2nd ____ 3rd ____
Student Activities: Freshman ____ Sophomore ____
Junior ____ Senior ____
Hobby? ____ Study most enjoyed at Purdue? ____
New object planned designed or built? ____
What percent of expenses earned in College and How? Freshman year ____ % ____ Sophomore Year ____ %
Junior Year ____ % ____ Senior Year ____ %
Memberships: Church ____ Social Fraternity or Club ____
Honors and Honorary Organizations ____
Faculty or Committee Actions ____
Vocational Preference: As Freshman ____
As Junior ____
Work best fitted for with reasons ____
Work entered ____
REMARKS: ____

F. Tel. No. ____
J. Tel. No. ____
F. Univ. Address ____
J. Univ. Address ____
(Photograph and Debits Record in above Space)

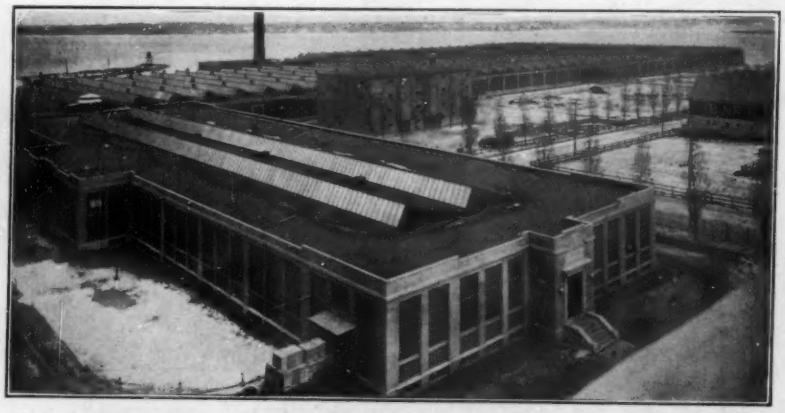
CHARACTERISTICS	FRESHMAN RATINGS: Teachers Grade / No.	Students Grade / No.	Others Grade / No.	Average Grade / No.	SOPHOMORE: Teachers Grade / No.	JUNIOR RATINGS: Teachers Grade / No.	Students Grade / No.	Others Grade / No.	Average Grade / No.	SENIOR: Teachers Grade / No.
1. Address and Manner:										
2. Attitude:										
3. Character:										
4. Cooperative Ability:										
5. Disposition:										
6. Industry:										
7. Initiative:										
8. Judgment:										
9. Leadership:										
10. Native Capacity:										
Rating Scale: Averages										

Academic Record	Number of Each Grade and Credit Hours: H / No.	A / No.	B / No.	F / No.	C / No.	D / No.	Gen. Aver. / No.
Freshman Year							
Sophomore Year							
Junior Year							
3 Years Total							
Senior Year							
4 Years Total							

Difficult Subjects? ____
Easy Subjects? ____

Knowledge of Fundamentals | Average | No. || Int. Tests
General Technique

Health Record: Medical Rating A.__ B.__ F.__ C.__ D.__
Physical Defects or Deformities ____
Hospital, ____, ____, ____, ____, ____,
Recent Sickness or Operation ____
Height 1st ____ ft. ____ in. Weight 1st ____ lbs.
Heigh 2nd ____ ft. ____ in. Weight 2nd ____ lbs.



One of the finest textile mills in the world, built by Wm. T. Reed Co. Several repeat orders have been received from this firm.

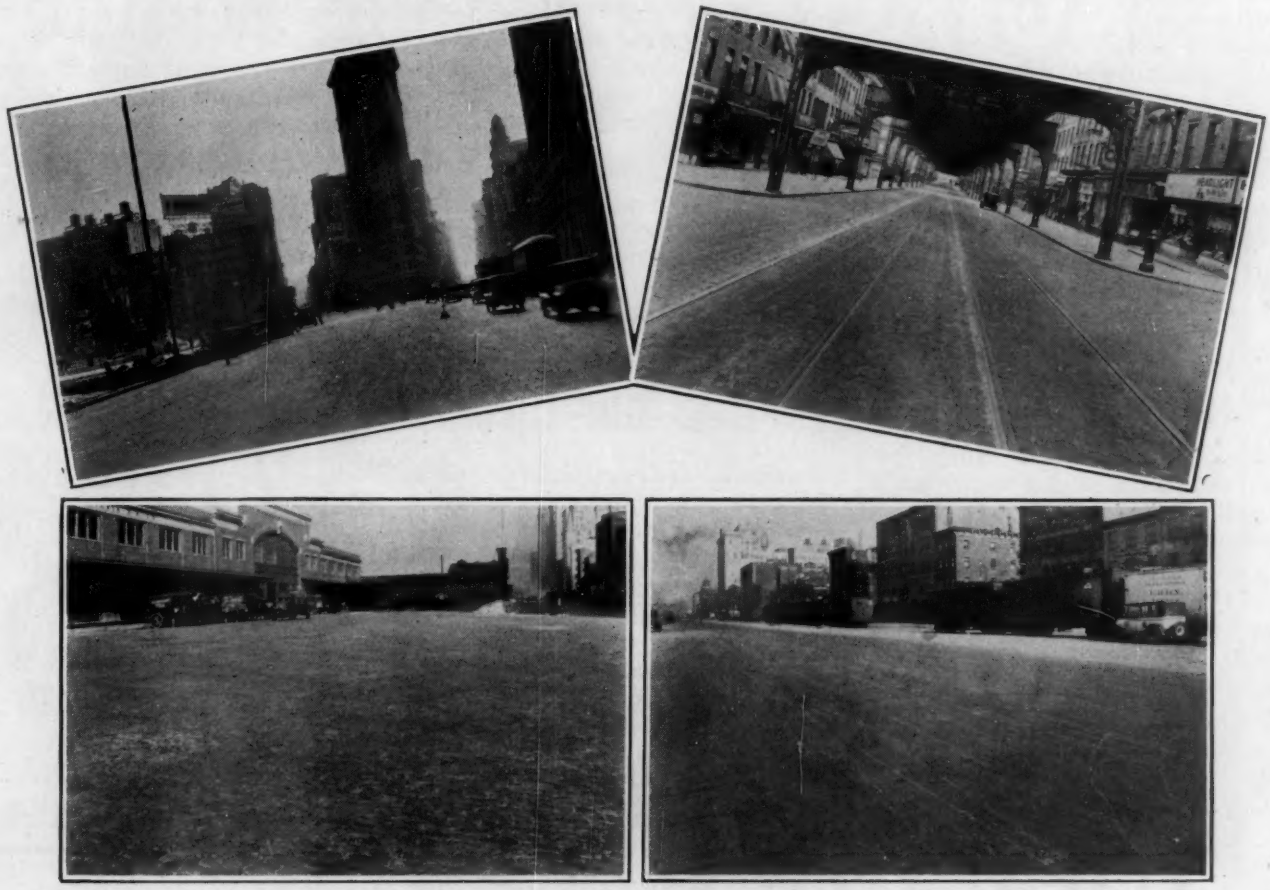
WILLIAM T. REED CO.

Building Construction

200 DEVONSHIRE STREET, BOSTON

We are organized and equipped for the efficient handling of mercantile and industrial building construction of all descriptions.

Granite Lives Forever



Where traffic is heavy pavement must last

It will last on all these heavy-traffic streets because they are paved with enduring Granite Blocks.

Solve your street paving problems for all time by specifying everlasting Granite Paving Blocks.

"Granite Street Construction" tells how best to do it. Ask for a copy.

Granite Paving Block Mfrs. Assoc. of the U. S. Inc.
31 State Street, Boston, Mass.
Representing The World's Greatest Granite Quarries

GRANITE · LIVES · FOREVER

Modern Fireworks

(Continued from page 340)

various color producing chemicals in proper proportion so that they will ignite easily and burn readily with as little smoke as possible. A flag is made of lances which are tubes about the size of a lead pencil into which the dry composition of the chemicals which will produce the desired colors and effect are packed. Each tube is so placed as to give shape and form to the picture and color to emphasize the desired effect.

After dipping the end of the lance in glue it is pushed firmly onto the nail imbedding it in the composition of the lance. The other end of the lance is primed with slow burning moistened gun powder. After the lances are placed in the proper position a line of pipe match is tacked onto the tops of the lances so that when they have all been connected together by means of quick "pipe match" the match may be ignited at one point and the fire flashes to all the lances at once, igniting the entire line. As these start to burn the pipe match drops off leaving the little balls of different colored fire to make the lines of the picture. These burn from one to two minutes, and a portrait in fire may be made wonderfully true to life.

The pyrotechnist's skill is not of the theoretical kind. It is not gathered from text books but is handed down from father to son, discoveries and improvements being made and added to the store by each successive generation. Pyrotechnical chemistry is still in its infancy and the future of the industry is governed only by the laws of chemistry—discovered and undiscovered—and by the ingenuity of the investigators.

The fireworks of the future will not be Roman candles in the hands of young America but will be magnificent displays of colored stars, wonderful bombshells, and beautiful set pieces with designs in both fixed and moving figures. The deafening noise that so often accompanies the present displays will be done away with, and in its place—the beautiful blending of splashes of color and changing figures and effects outlined against the clouds. These marvelous exhibitions of the future will probably be given largely by the municipalities for the benefit of all and with a correspondingly decreased risk to the individual.

Aerography

(Continued from page 315)

And here we may explain that aerographers make use of what is known as the geostrophic or gradient wind. The most natural assumption regarding surface air flow is that since pressure determines air motion the winds would flow according to the direction and steepness of the pressure gradient, that is the distance between the isobars. At a height of about 500 meters the wind is free from surface friction, and other things being allowed for the air will flow along the isobars, being of course prevented from direct flow toward the center of rotation by the centrifugal tendency. The relation must not be pressed too far however. And it must not be forgotten that the whole relation depends upon the assumption of balanced forces.

Those interested in the practical application of this method of obtaining the normal gradient air flow appropriate for any given surface distribution of pressure will find a chapter in Shaw's "Forecasting Weather," 2d Edition, very informative, particularly

(Continued on page 346)

Laboratory Equipment

K KNOTT

Industrial & Educational

L. E. KNOTT APPARATUS COMPANY

CAMBRIDGE MASSACHUSETTS

SINCE 1895

The Standard for Rubber Insulation

OKONITE TRADE MARK

RUBBER COVERED AND VARNISHED CAMBRIC

WIRES and CABLES

are made with especial regard for Quality

All OKONITE products are carefully inspected and tested at each step in the manufacturing process so as to insure a perfect finished result.

Full details in Handbook—Send for it.

The Okonite Company

The Okonite-Callender Cable Co., Inc.

Factories, PASSAIC, N. J. PATERSON, N. J.

Sales Offices: New York, Chicago, Pittsburgh, St. Louis, Atlanta, Birmingham, San Francisco, Los Angeles, Seattle

OKONITE

Pettingell-Andrews Co., Boston, Mass.
Novelty Electric Co., Philadelphia Pa.
F. D. Lawrence Elec. Co., Cincinnati, O.

Canadian Representatives: Engineering Materials Ltd., Montreal
Cuban Representatives: Victor G. Mendoza Co. Havana

HE DIRECTS THE LIGHTNING —SUMMONS THE EARTHQUAKE

To control the elements; to direct the lightning and harness the hurricane; to summon the earthquake and bend its devastating forces to man's will—this is a dream that has captivated the imagination since man first gazed in terror at one of Nature's furious assaults.

It is for the Explosives Engineer to realize this dream. Forces as potent as those let loose by Nature in her blindest rages are under his control. In modern industry there is nothing more romantic than his mastery of the tremendous power of dynamite; his ability to guide this power to perform his useful work; to make it conform to his charts and calculations.

Without the precise knowledge and experience of the Explosives Engineer, dynamite may be a wasteful and uncertain force; and waste and uncertainty are costly. Leaders of the mining, quarrying, and construction industries are realizing this more and more. They are looking for men who can eliminate waste and uncertainty in their blasting.

As an aid to engineering students who would like to fit themselves for this new branch of engineering, the Hercules Powder Company has issued many booklets dealing with explosives and the technic of their use; these are yours for the asking. *The Explosives Engineer* is a monthly publication dealing with blasting and allied subjects. Each issue contains information of interest and value to the engineering student or graduate. Mail the coupon on the right for a free sample copy.

HERCULES POWDER COMPANY
(INCORPORATED)
Wilmington Delaware

MANY discerning engineering students are preparing themselves for future promotions *now* by reading The Explosives Engineer, regularly. And they are finding that this foresight does not involve arduous effort. Anyone wishing to learn more about mining, quarrying and construction will derive pleasure as well as profit from the carefully edited, authoritative articles and from the many photographs, drawings, paintings, and other illustrations.

Each issue contains a bibliography of everything published in the technical press of the world, relating to drilling and blasting.

Supplement your classroom instruction with this wealth of useful information from men who are now occupying the jobs to which you will some day aspire.

Mail this coupon for a free sample copy.

THE EXPLOSIVES ENGINEER
941 Delaware Trust Building
Wilmington, Delaware.

Please send me a free sample copy of The Explosives Engineer.

NAME

STREET

CITY

STATE

Aerography

(Continued from page 344)

the discussion on the Approach of Depressions.

Our views regarding the efficiency of thermal convection have been modified in late years, and stress is now laid upon the mechanical mixing or upsetting of a warm air mass by a cold mass. Cold air may even find its way upward in spite of gravitational effects. And the same process may occur with water vapor, altho it is to be remembered that air becomes heavier with falling temperature while the reverse is true for water vapor. The dynamical motion due to eddies or some forced intrusion, may entirely overcome motion initiated by thermal conditions. Such views of course lead to a questioning of explanations hitherto accepted regarding the origin of the great steady air streams, the trade winds for example. Heat supposedly caused convection, but we really do not know. If however we pass from major air streams to minor circulations we find a modern view of the origin of storms in a struggle for position between projecting tongues of polar air, under running masses of equatorial air. It is a wedge effect and the ensuing rainfall is quite naturally regarded as a consequence occurring as it seems to do, along the so-called steering line or line or uplift and later rain along the squall line or line of discontinuity.

So we are come a long way from the old theory of an indraft of warm air and an anti-clockwise whirl as the essential features of a depression, while cool, dry, descending air with a clockwise circulation marked the anticyclone or high.

A very recent contribution to our knowledge of the physical structure of the atmosphere is the devising of a series of curves of reference. Sir Napier Shaw stated in one of his lectures on the "Air and its Ways" that he had for many years wanted an indicator diagram which would set forth the usual results of a sounding in a way that would show at a glance the relation of potential temperature to kinetic energy. That is, he sought a graphical method transforming the graph of log pressure and log temperature into log of pressure and log of potential temperature.

The log potential temperature, he suggests might well be named *entropic temperature* and it is proportional to the "realized entropy" of the air. And so we have a diagram on which area represents thermal energy. Shaw calls it a tephigram (from T, p, and gram) temperature, entropy and weight.

We may not in this article reproduce the diagrams from Shaw's recent papers on the Physical Structure of the Atmosphere from the Dynamical Point of View; The Energy of Saturated Air in a Natural Environment and Resilience, Cross Currents and Convection. Enough to say that from the graph of any sounding we can now give the conditions of environment. The area inclosed if on the warmer side of the curve of environment shows "the energy developed spontaneously by one kilogram of air, saturated at the temperature of the starting point." In a given example the area represents about 700 joules or watt-seconds. A cubic kilometer of air so disposed of would display a surplus energy of about 6×10^8 kilowatt seconds or nearly two hundred thousand kilowatt hours.

(Continued on page 348)

BAY STATE
DREDGING & CONTRACTING CO.
Contractors

River and Harbor Improvements

Sea Walls

Breakwaters

Heavy Masonry Construction

Concrete and General Contracting

View showing progress being made on proposed 600′ timber wharf, bulkhead and sea wall, for the Lynn Gas & Electric Co., Lynn, Mass., now under construction.

OFFICE
EAST BOSTON, MASS.
62 CONDOR STREET
TELEPHONES
East Boston 1834 *and* 1835

GORHAM H. WHITNEY, *President*
JAMES E. CASHMAN, *Treasurer*
DAVID J. WHITE, *Gen'l Manager*

Food *for* Thought

An independent engineering organization recently made a survey of fuel costs in the plant of a nationally-known company that had changed over to gas, for a large part of of its production eighteen months previously. The following quotations, taken directly from the engineer's report, show some of the advantages effected in this plant through the use of gas:

"Cost reduced 28%"
"Annual saving $3,676.32"
"Net yearly return of 102% on investment"
"Gas more dependable"
"Faster heating"
"More accurate temperature control"

Here indeed is food for thought. Perhaps right now you are wondering what gas would do in *your* plant. Our interesting book, "Gas—The Ideal Factory Fuel" will prove helpful to you. Why don't you send for your copy now?

American Gas Association
342 Madison Avenue, New York City

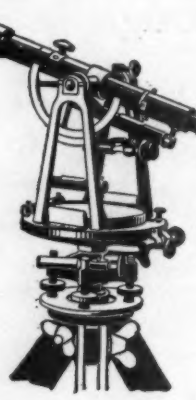
YOU CAN DO IT BETTER WITH GAS

Aerography

(Continued from page 346)

Now is this surplus thermal energy transformed into kinetic energy resulting in horizontal or vertical motion? If as Shaw suggests we call this surplus energy "commotional energy" and study it in connection with storm development and transition, we may be able in time to measure the directional forces of moving air masses.

It is to be noted that in all this work, stability is dependent not on temperature but rather on the potential temperature of the environment.



Engineers and contractors know that BUFF performance is accurate and sure—on all sorts of work, from running location lines to giving "neat lines" on important bridgework—without having to adjust the transit once.

Write for the BUFF Catalog No. 20M

Buff & Buff Mfg. Co.

Jamaica Plain, Mass.

BUFF

TRADE MARK TRADE MARK

A Study of Brick Pavements

(Continued from page 318)

The Indications of the Field Study Summarized

A steady growth in the use of brick of less than 3-inch depth is shown by the field survey. Numerous communities were found which have adopted the thinner brick for use in some or all of their streets. Although the earlier work may be classed as experimental, as indicated by the small quantities put down and by the type of street selected for paving, subsequent paving with the thin brick in larger quantities and on streets carrying heavier traffic may well be taken as an expression of the satisfaction of the community with pavements of this type.

The pavements built with 2 1/2-inch brick, in most cases, were in good condition. In a few localities failures had occurred in the base causing displacement in the brick. It was particularly noted that in such cases displacement in the brick had taken place without breakage. This was found to be true also for the brick over transverse and longitudinal cracks.

The importance of limiting the quantity of asphalt filler to that required to fill the space between the brick was strikingly illustrated by the unsatisfactory condition of such pavements.

Some changes in the construction features of brick pavements have occurred since the earlier pavements were laid. The bedding course of the early surfaces was found to range in thickness from 1 1/2 to 2 inches laid on a rough base. Later construction shows, generally, that a 3/4-inch bedding has been used on a smoothly finished base. In a few localities very fine sand had been used for bedding, but, because this type of sand shows a tendency to work up between the brick and because of loss through cracks in the base, coarser sand has been substituted as being more satisfactory.

The field survey showed that, in general, brick laid on a thin bedding course with a smoothly finished base maintained a smoother surface than those laid with a greater depth of sand on a roughly finished base.

The research of the last few years has proved that the destructive effect of motor-truck impact is greatly reduced by the construction of smooth pavement surfaces. The continued perfect alignment of the heavy traffic thoroughfares, on the smoothness with which the base course is finished and the resulting uniformity of thickness and compaction of the bedding course. Any slight increase in the construction cost for the purpose of obtaining this condition will be more than justified by the potential increase in the life of the pavement.

A wide range in the type and construction of base used was noted in the survey. Concrete ranging from 4 to 6 inches in thickness and largely of 1:3:5 proportion was found to have been used extensively in the area covered, while old and new macadam had been used satisfactorily in many instances. One city in the iron-ore belt was utilizing the iron-ore-soil with entirely satisfactory results as base for brick pavements.

A great deal of importance is attached, and properly so, to the views and experience of resident engineers and officials familiar with the use of brick under 3 inches in thickness. All of the officials interviewed from those sections of the country where brick of less than 3-inch thickness is being used expressed themselves as favorable to the use of the thinner brick, some with and others without limitations as to the type of street and traffic. Many maintained that 2 1/2-inch brick would prove equally as satisfactory as the 3-inch thickness under all conditions, and others believed that the 2 1/2-inch type should be limited to use on residential and outlying business streets.

SAMSON SPOT SASH CORD

Trade-Mark Registered U. S. Patent Office

Made of extra quality cotton yarn, carefully inspected, and guaranteed free from all imperfections of braid or finish. The colored spots are our trade-mark, used only with this quality.
We make braided cord of all sizes, kinds, and colors, for all purposes, including sash cord, clothes lines, trolley cord, signal cord, arc lamp cord, and many special cords for special purposes.
CATALOGUE AND SAMPLES GLADLY SENT ON REQUEST

SAMSON CORDAGE WORKS -:- **88 Broad Street, Boston 9, Mass.**

To the RAILROAD MEN *of* AMERICA

AN OPPORTUNITY IS RIPE for saving about seven-eighths of the power now needed to start trains.

Hence heavier freights and smoothest passenger service are practical with present motive power.

A major economy can also be effected in car lubrication. Most of this cost is avoidable, with every requirement of maintenance and safety being met by journal inspection months apart! *Yet hot boxes will become unknown.*

Indeed, all the chief causes of wear and tear disappear from trucks and draft gear, as the old sliding friction in journals is supplanted by perfectly lubricated rolling motion, confined entirely to hardened, ground, special alloy steel, of utmost durability.

An established, conservative, highly successful, world-respected engineering institution sponsors all this. It is being accomplished today by means of Timken Tapered Roller Bearings. They have become universal throughout transportation and other industries.

Data on Timken Bearings in car journals, and any desired engineering counsel, are at the disposal of every railroad. THE TIMKEN ROLLER BEARING CO., CANTON, OHIO

H. H. Timken

The Pictorial Section

(Continued from page 322)

pany have incorporated a Hartford shock absorber into their steering system on the big six operating between the tie rod and the axle to prevent wobble.

Detail refinements have been made and one shot lubricating systems are becoming more popular. These make lubricating the car less tedious, hence increasing the life of parts which would never be lubricated if grease cups were required.

In the field of bodies, the only tendencies worth mentioning are the increase in popularity of nitro-cellulose finishes such as duco colored with pigment and the adoption of the Weyman fabric body by certain custom body makers.

While the cars of the coming year will require less servicing than any of their predecessors, such servicing as is necessary may be very readily accomplished. All engineers have considered accessibility in their designs and most unit assemblies may be removed from the car and disassembled in a very short time. The factories have used greater care in manufacturing than before, making for greater wearing qualities. A great many companies have developed special devices to detect imperfections in production.

The Franklin Co. is now using a radio device to test for rear axle noises. All of the larger producers are annually expending fortunes on research which makes for a better product in the hands of the consumer.

The General Motors Co. have taken the initiative in this respect by the establishment of a proving ground near Detroit for the use of their divisions. This plant is completely equipped for speed testing and simulating actual road conditions. One of the most interesting features of the proving ground is the "Bathtub" consisting of a section of road in which an artificial puddle of a depth of 30 in. is created. Cars are driven through this to see if windshields get splashed too much, if the floor boards leak water, if the water will get in the carburetor, and many other similar questions of interest to designers. This gives only one example of the many types of research being conducted to improve the modern car.

A. K. Stricker, Jr.

Recent Books

(Continued from page 330)

of classical mechanics, which has since forced itself to the fore with such relentless vigor, and Planck's quantum theory makes its appearance. In the third paper (1906) it is shown how and when previous results can be applied to determine the dimensions of the molecules of a dissolved substance from a knowledge of "the viscosity of the solution, and of the pure solvent, and (of) the rate of diffusion of the solute into the solvent." The fourth and fifth papers are essentially a simplified exposition of ideas already developed, and are intended to facilitate the task of the experimenter in interpreting his results.

Of the substance of the papers little need be said: they are of the nature of fundamental contributions to the knowledge of unexplored regions of physical science. One admires Einstein's resourcefulness and his keen insight into the physical nature of the phenomenon he is studying, coupled with a mastery of analysis such as are seldom seen together. Fürth's notes are in general adequate and to the point, but even with their help the text will prove too technical for the average reader looking for information only. On the other hand, they will prove invaluable to the serious student.

The translation is awkward and slipshod in spots. The reader is made to feel constantly the German ancestry of the sentences and often an attempt at clarity of expression ends only in pitiful dilution. None who can read Einstein's vigorous German original will be satisfied with this English translation.

M. S. Vallarta

TECHNOLOGY BRANCH

76 Massachusetts Ave., Cambridge, Mass.

We have secured a limited number of the four dollar edition of
James Phinney Munroe's

Life of Francis Amasa Walker

President of Massachusetts Institute of Technology 1881-1897

These will be sold for one dollar a copy postpaid to any address in the United States until the supply is exhausted.

Mail orders will be filled in rotation as received

Technology Branch

HARVARD CO-OPERATIVE SOCIETY

Elementary Brickology

Lesson No. 1

No vitrified brick pavement ever wore out from the top down.

Lesson No. 2

The ABC of Good pavements is *A*sphalt for *filler*, *B*rick for *surface*, *C*oncrete, *C*rushed Slag, *C*rushed Rock (Sand or Gravel) for *base*.

Lesson No. 3

Vitrified brick builds the only pavement with *two-sided* value.

A Book for Roads Scholars

—yours on request

To keep taxes from climbing, advocate

VITRIFIED Brick

OUTLAST THE BONDS

NATIONAL PAVING BRICK MANUFACTURERS ASSOCIATION, ENGINEERS BLDG., CLEVELAND, OHIO

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CAMBRIDGE, MASS.

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY offers Courses, each of four years' duration, in Civil, Mechanical, Electrical and Aeronautical Engineering; Naval Architecture and Marine Engineering; Mining Engineering and Metallurgy and Geology; Architecture and Architectural Engineering; Chemistry, Chemical Engineering and Electrochemical Engineering; Biology and Public Health and Sanitary and Municipal Engineering; Mathematics, Physics, General Science and General Engineering; and in Engineering Administration. These Courses lead to the degree of Bachelor of Science.

To be admitted to the first year class applicants must have attained the age of seventeen years, and must satisfactorily fulfill entrance requirements in Algebra, Plane and Solid Geometry, Trigonometry, Physics, Chemistry, English, History and French or German and two units of elective subjects. Examinations are required in all subjects except Chemistry, History and the electives, the requirements for which are fulfilled by the presentation of satisfactory certificates. A division of these entrance subjects between different examination periods is permitted.

Entrance examinations are held at the Institute in September. In June applicants will be examined by the College Entrance Examination Board in Boston, New York, Philadelphia, Chicago and many other cities in America and Europe. A circular stating times and places is issued in advance by the College Board.

Graduates of colleges and scientific schools of collegiate grade, and in general all applicants presenting satisfactory certificates showing work done at another college corresponding to at least one year's work at the Institute, are admitted, without examination, to such advanced standing as is warranted by their previous training.

Graduate courses leading to the degrees of Master of Science, Master in Architecture, Doctor of Philosophy, Doctor of Science and Doctor of Public Health are also offered. Special Research Laboratories of Physical Chemistry, Organic Chemistry, Applied Chemistry and Science have been established.

Correspondence should be addressed to the Institute of Technology.

PUBLICATIONS

Catalogue; Bulletins of General Information, Summer Session, and Graduate Study and Research; and the Report of the President and the Treasurer.

Any of the above named publications will be mailed free on application.

For information, address

ADMISSIONS OFFICE

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CAMBRIDGE A, MASS.

THE TECH ENGINEERING NEWS

VOLUME VII

INDEX

MARCH, 1926—JANUARY, 1927

A

Subject and Author	*Month*	*Page*
Aborn, R. H., '20, and Brugmann, E. W., '24 — X-Rays and the Ultimate Structure of Metals	April	54
Abrasives — John B. Glaze, '12	October	175
Advanced Boiler Practice — Prof. E. F. Miller, '86	December	259
Aerography — McAdie, Alexander	January	314
Airplane Propeller Interference Study — S. Ober, '16	March	12
Ames, Aubrey P., '19 — The Engineer in Export Business	November	215
Application of Electricity to Railroads — Arthur J. Marson, '05	April	60

B

Bacteria, the Smallest Workers in Industry — B. E. Proctor, '23	May	110
Baker River Power Development, The — W. D. Shannon	March	16
Balsbaugh, Jay, '24 — Hydro-Electric Power Stations	November	220
Blackall, Robert M., '17 — The Trend of Modern American Architecture	May	116
Bowie, William — The Coast and Geodetic Survey	October	168
Brugmann, E. W. '24, and Aborn, R. H., '20 — X-Rays and the Ultimate Structure of Metals	April	54
Buckingham, Prof. Earl		
Engineering Measurement Standards	April	52
Inspection Methods	May	118
Measurements and Units of Measure	March	8
Burtner, Prof. Evers, '15		
Some Unusual Marine Accidents	May	114

C

Clair, Miles N., '23 — Modern Concrete Construction	March	14
Clapp, James K., '23 — Short-Wave Radio Communication	March	9
Clark, A. F. — Modern Fireworks	January	312
Clarke, C. W. E. — Steam Power Stations	December	266
Coast and Geodetic Survey, The — William Bowie	October	168
Collins, John A., Jr., '97 — The Technical Graduate in the Textile Industry	April	51
Conowingo — G. R. Strandburg	November	218

E

Engineer in Export Business, The — Aubrey P. Ames, '19	November	215
Engineering—Legendary Kingdom of Midas — Frank M. Gentry, '23	October	174
Engineering and Human Progress — A. A. Potter	October	164
Engineering Measurement Standards — Prof. Earl Buckingham	April	52

F

Fahrenwold, A. W. — Ore Concentration by Flotation	October	172
Finding an Anti-Knock Material — Thomas Midgely, Jr.	May	119
Foreign Telephone Systems — John J. Parsons, '24	April	56

G

Gentry, Frank M., '23 — Engineering Legendary Kingdom of Midas	October	174
Glaze, John B., '12 — Abrasives	October	175
Griffin, Martin L. — The Technical Graduate in the Paper Industry	March	7

H

Hydro-Electric Power Stations — Jay Balsbaugh, '24	November	220

I

Inspection Methods — Prof. Earl Buckingham	May	118

J

Jordan, Edward S. — The Technical Graduate and Transportation	January	311

L

Lee, Elisha, '92 — Present Day Problems of Railroad Management	April	53
Letter from an Engineering Executive to His Son	May	107

M

McAdie, Alexander — Aerography	January	319
Malolo, The S. S. — E. P. Trask, '99	May	112
Mangelsdorf, T. A., '26 — The Role of Chemistry in Power Generation	December	268
Manson, Arthur J., '05 — The Application of Electricity to Railroads	April	10
Martin, E. D., '22 — Metal Plating with Gases	March	10
Meadowcroft, J. W. — Welding All-Steel Automobile Bodies	January	319
Measurements and Units of Measure — Prof. Earl Buckingham	March	8
Metal Plating with Gases — E. D. Martin, '22	March	10
Metalclad Rigid Airship Development — Ralph Upson	April	57
Midgely, Thomas Jr. — Finding an Anti-Knock Material	May	119
Miller, Prof. E. F., '86 — Advanced Boiler Practice	December	259
Modern Concrete Construction — Sanford E. Thompson, '88 and Miles N. Clair, '23	March	14
Modern Fireworks — A. F. Clark	January	312

N

National Air Races, The — Max Short, '26	October	166
Norton, Prof. John T., '18		
X-Rays	October	163
X-Ray Spectroscopy	November	216
Radiography	December	263

O

Ober, S., '16 — Airplane Propeller Interference Study	March	12
Open House Night	April	62
Ore Concentration by Flotation — A. W. Fahrenwold	October	172

P

Parsons, John J., '24 — Foreign Telephone Systems	April	56

INDEX *(Continued)*

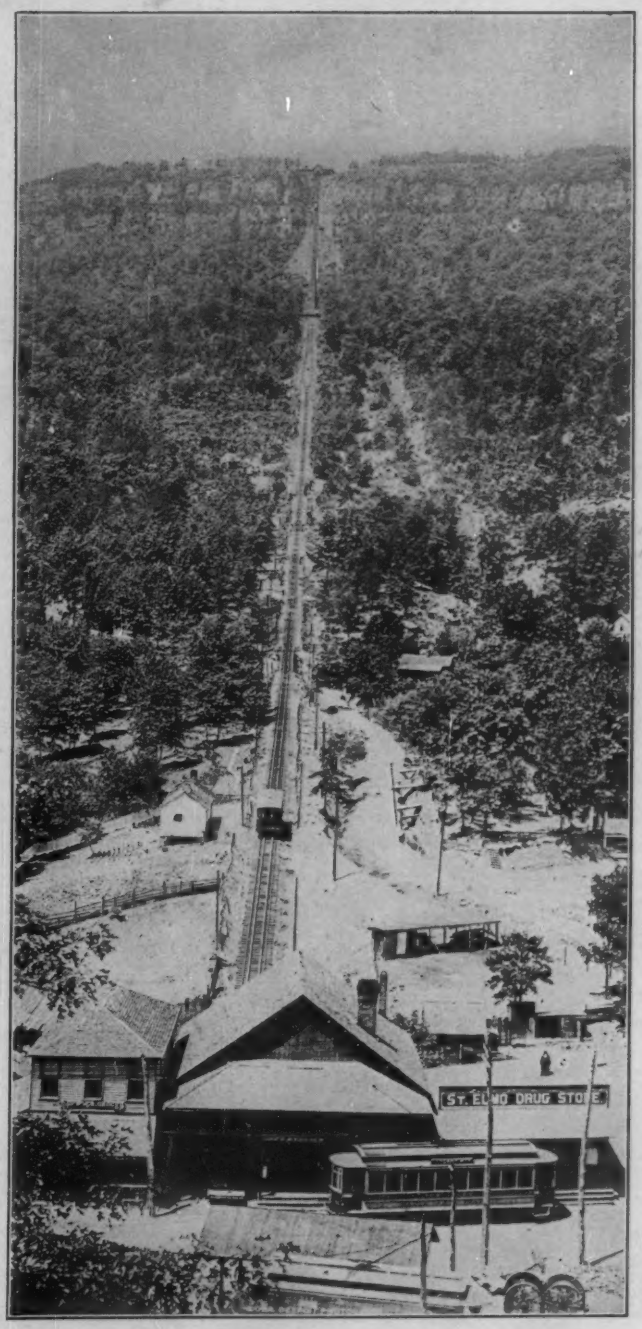
Subject and Author	*Month*	*Page*
Patart, General Georges Synthetic Methanol and Liquid Fuels from Coal	December	260
Pauls, J. T., and L. W. Teller A Study of Thin Brick Pavements	January	316
Peavey, Leroy D., '98 Planning a Career, The 1926 Graduate	May	108
Planning a Career—The 1926 Graduate Leroy D. Peavey, '98	May	108
Potter, A. A. Engineering and Human Progress	October	164
Present Day Problems of Railroad Management Elisha Lee, '92	April	53
Proctor, B. E., '23 Bacteria, the Smallest Worker in Industry	May	110
Purdue's Personnel System J. E. Walters	January	321
R		
Radiography Prof. John T. Norton, '18	December	263
Role of Chemistry in Power Generation, The J. T. Ward and T. A. Mangelsdorf, '26	December	268
S		
Shannon, W. D. The Baker River Power Development	March	16
Short, Mac, '26 The National Air Races	October	166
Short-Wave Radio Communication James K. Clapp, '23	March	9
Steam Power Stations C. W. E. Clarke	December	266
Strandberg, G. R. Conowingo	November	218
Synthetic Methanol and Liquid Fuels from Coal General Georges Patart	December	266
T		
Technical Graduate and Transportation, The Edward S. Jordan	January	311
Technical Graduate in the Paper Industry Martin L. Griffin	March	7
Technical Graduate in the Textile Industry John A. Collins, Jr., '97	April	57
Teller, L. W., and J. T. Pauls A Study of Thin Brick Pavements	January	316
Thin Brick Pavements, A Study of L. W. Teller and J. T. Pauls	January	316
Thompson, Sanford E., '88 Modern Concrete Construction	March	14
Trask, E. P., '99 The S. S. Malolo	May	112
Trend of Modern American Architecture, The Robert M. Blackall, '17	May	116
U		
Unusual Marine Accidents, Some Prof. Evers Burtner, '15	May	114
Upson, Ralph Metalclad Rigid Airship Development	April	57
W		
Walters, J. E. Purdue's Personnel System	January	321
Ward, J. T. The Role of Chemistry in Power Generation	December	268
Welding All-Steel Automobile Bodies J. W. Meadowcroft	January	319
X		
X-Rays Prof. John T. Norton, '18	October	163
X-Rays and the Ultimate Structure of Metals R. H. Aborn, '20 and E. W. Brugmann '24	April	54
X-Ray Spectroscopy Prof. John T. Norton, '18	November	216

A Good Mountain for Lazy Bones

WHY not be a mountaineer? From the top of Lookout Mountain, near Chattanooga, you may gaze over one of the finest panoramas in the country, and at the same time experience that peculiar thrill which only historic scenes can inspire.

The answer, you think, is obvious You will leave mountain climbing to those who prefer a withered sprig of edelweiss to the most beautiful rose from an old-fashioned garden; who would rather grasp an alpenstock than the hand of a friend.

Perhaps, then, you do not know that the Otis Company, which lifts men so easily to their offices every morning, is ready to lift you just as easily to the summit of Lookout Mountain, on the Otis Inclined Railway.



THE WORLD'S WORD FOR ELEVATOR SAFETY
Otis

OTIS ELEVATOR COMPANY

Offices in all Principal Cities of the World